PERKIN-ELMER
AEROSPACE DIVISION

NASA CR
141884

# SPACE SHUTTLE
## AUTOMATIC EXPOSURE IRIS CONTROL

## FINAL REPORT

(NASA-CR-141884) AUTOMATIC EXPOSURE IRIS CONTROL (AEIC) FOR DATA ACQUISITION CAMERA Final Report (Perkin-Elmer Corp.) 69 p HC $4.25 CSCL 14E
N75-26341
Unclas
G3/35 27300

THE PERKIN-ELMER CORPORATION
AEROSPACE DIVISION
2771 North Garey Avenue, Pomona, California 91767

# AUTOMATIC EXPOSURE IRIS CONTROL (AEIC) FOR DATA ACQUISITION CAMERA FINAL REPORT

by

George E. McAtee Jr., Louis J. Stoap,
Curtis D. Solheim, James T. Sharpsteen

April 1975

Perkin-Elmer SPO 30284-00800
NASA Contract Number NAS9-12790

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Johnson Space Center
Houston, Texas 77058

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# 1. INTRODUCTION

The following final report is submitted in conformance with Exhibit "A" of the Statement of Work under Contract NAS9-12790, for an Automatic Exposure Iris Control (AEIC) system including a 10mm f/1.4 lens, incorporated on an existing 16mm Data Acquisition Camera (DAC) furnished by the Government.

The major objectives of the design were as follows:

a. Supply a lens design capable of operating over a total range of f/1.4 to f/22.0 with through the lens light sensing.

b. Supply a system which will compensate for ASA film speeds as well as shutter openings.

c. Make minimal modifications to the existing Data Acquisition Camera, and not degrade the performance of the camera in any way.

The design review for the AEIC was held at the Perkin-Elmer, Aerospace Division facility in June, 1974. At that time, a formal report was presented covering the electronic design, mechanical design, and optical design of the system. Following the design review, the AEIC was fabricated and assembled on an existing Data Acquisition Camera, and tested in accordance with the approved test procedure.

The AEIC met all of its design goals with two exceptions, both in connection with the lens. Whereas the lens speed was specified f/1.4 to f/22.0, the actual range turned out to be f/1.4 to f/11.0 plus 1/4 stop, or 1-3/4 stops short of the goal. This limitation is due to the iris design, and is related to the small lens package size. An improvement within this envelope may be difficult to achieve, but is not necessarily impossible. The total iris range can of course be achieved with a larger lens barrel design.

The remaining problem is related to interference between the focus ring, which moves along the barrel as focus is changed, and the body which houses the AEIC. In the present design, this interference prevents the lens from focusing closer than 12 inches, although the lens itself can focus down to 8 inches, in conformance with the specification. This is a minor problem which can easily be corrected by a simple re-design of the mechanical parts.

The lens met its design requirements in all other respects, and in the area of resolution it exceeded the requirement of 250/line pairs per millimeter on axis, recorded on 3414 film.

The mechanical and electronic designs met all of their requirements, but one design detail needs further discussion. In order to avoid the requirement for

technicians to set an extra switch for shutter speed compensation, a switch was incorporated into AEIC, directly coupled to the existing speed selector knob on the DAC. In line with the total concept for the AEIC, this design was made so as to effect minimum changes to the existing DAC parts. This switch proved to be completely satisfactory in laboratory tests, but because it is an open switch and uses sliding contacts, there is some concern for its potential re-lliability in space applications. Several approaches are available for replacing this design with one which would qualify for application in a space qualified camera.

This final report consists of the design review report, updated to include minor changes which occurred during fabrication and test, photographs of the finished hardware, the specification for the lens, the formal test procedure, and the test data. To avoid unnecessary expense, grammatical changes to the design review report (such as verb tense to change the time reference) were not made, because this was not considered to be of sufficient importance to the understanding of the report. In Figure 2-1, the line drawing of the DAC with AEIC has been replaced with a photograph of the actual hardware. In Section 5 (Optical Design), "existing 10mm lens" refers to the Kern lens provided to Perkin-Elmer by NASA for evaluation purposes as part of the optical study.

## 2. SYSTEM DESCRIPTION

The AEIC system utilizes all applicable sections of Tasks 1 through 6 of NAS9-12790. Since only the iris is to be automatically adjusted in achieving automatic exposure control, the system has been considerably simplified. Shutter control is manual and requires no modifications to the existing camera. The method of iris control is accomplished essentially in the same manner as in the design of the earlier tasks, except that electrical feedback of the iris position is not required, eliminating the need for a potentiometer or encoder wheel. However, a means to detect when the fully open or fully closed iris position have been reached, is required for the electronic logic design. These features are discussed in detail in Sections 3 and 4 of this report.

Figure 2-1 illustrates the Space Shuttle Camera system package. It is designed so that it can be assembled to the existing 16 mm DAC with a minimum of alteration to the camera. The physical changes and structural details are discussed in Section 4. In addition, the package has been designed to add minimal size and weight to the DAC.

With the AEIC installed on the DAC, there is no provision for local actuation of the system. The system is manually adjusted before flight, for frame rate, shutter speed and film ASA. The system is actuated by remote signal, with continuous automatic control of the iris during operation.

The system accomplishes Automatic Exposure Control, AEC, by adjustment of the iris and through variable inputs for shutter speed and ASA ratings. This design approach simply provides for an overall feedback between the light sensor and the iris. Separate feedbacks are not required for the iris and shutter settings, with the exception of the end point detectors to tell the electronic logic, whether either the fully open or fully closed positions have been reached.

The system is designed to control iris adjustment in increments of 1/4 f-stops for a total range of nine f-stops, or thirty-two 1/4 f-stop increments.

Although shutter control is not included in the feedback loop, the five manual shutter speed settings of 1/1000 through 1/60 second must be communicated to the electronics to provide proper compensation in the iris opening.

To avoid burdening the camera operator with additional switch settings, the shutter speed compensation switch is mechanically incorporated into the existing manual shutter speed adjustment. This design is discussed in Section 4.

Another manual switch in the AEIC provides iris compensation for ASA film values.

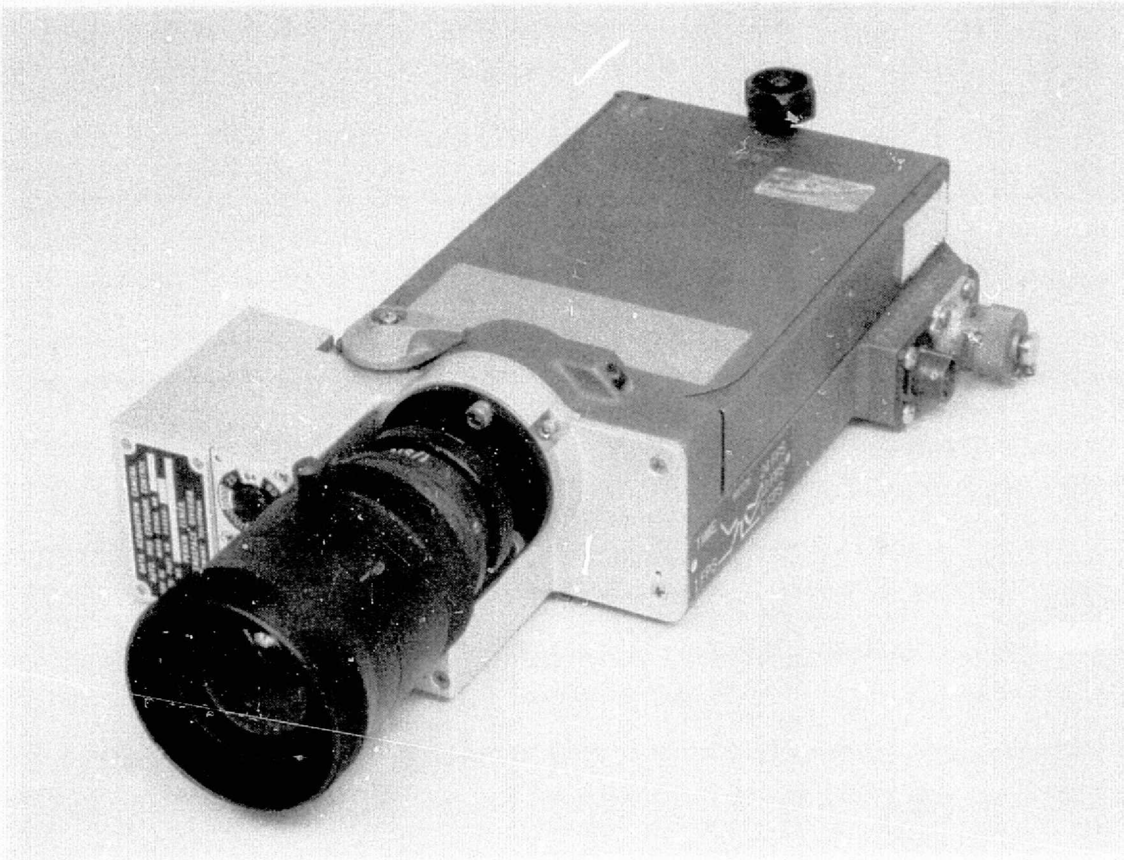


FIGURE 2-1. Data Acquisition Camera AEIC System Package

The camera lens is capable of operating over a nine f stop range, from f/1.4 to f/22.0, employs a linear iris, is focusable from 200 mm to infinity, and has a flange mounting surface. The linear iris ring turns an equal number of degrees for each f-stop. The focus ring turns without increasing or decreasing the length.

The optical design includes 11 lens elements, and one beamsplitter cube. This cube directs as much as 10% of the transmitted light through a single one element lens to a planar diffused silicone photodiode, which operates in the photovoltac mode. The single transmitting lens is designed such that it fills the total cell area. Other design information is set forth in Section 5.

# 3. ELECTRONIC DESIGN

A specific set of objectives have been established to provide a baseline for the electronic design for the Space Shuttle Camera. These objectives are summarized below.

a. Iris Control Range - Nine f-stops, 1.4 thru 22.

b. ASA Compensation - Compensation shall be to the closest 1/2 stop for the following ASA standards: 25, 64, 80, 160, 250, 500, 1000, 2000.

c. Shutter Speed Compensation - Full stop compensation shall be provided for shutter speeds of 1/60, 1/125, 1/250, 1/500, and 1/1000.

d. Light Range - 0.5 to 120,000 foot lamberts.

e. Minimal Interface - Three wires: +28 V dc, Q3-C, ground, Q8-E, and +14 V dc, Q3-E.

f. Power Consumption - +28 V dc, less than 100 mA; +14 V dc, less than 25 mA. Power to be drawn only when camera is triggered.

g. Temperature Range = -55°C to +85°C.

h. Input Voltage Variation - The exposure control shall perform with an input voltage variation to the camera of 24-32 V dc.

i. EMI and Isolation - Add on design shall not degrade present system capability.

j. Compensation Response Rate - 2.5 ±5% stops/second.

k. Resolution and Accuracy - Resolution of the system shall be 1/4 stop increments. Accuracy of the electronics shall be defined as follows: with an input light level of 220.8 fL, the system shall be nulled utilizing an ASA setting of 250, a shutter speed setting of 1/250 and an iris opening of f/5.6. By varying the input light level ± five stops from the initial setting and taking a corresponding opposite action utilizing the ASA and shutter speed settings, a null shall be achieved which does not exceed 1/16 of a stop.

## 3.1 OPERATIONAL DESCRIPTION

A block diagram of the system electronics is shown in Figure 3-1. Detail schematics of the analog and digital circuitry are shown in Figures 3-2 and 3-3 respectively. A system interface with the camera electronics consists of three

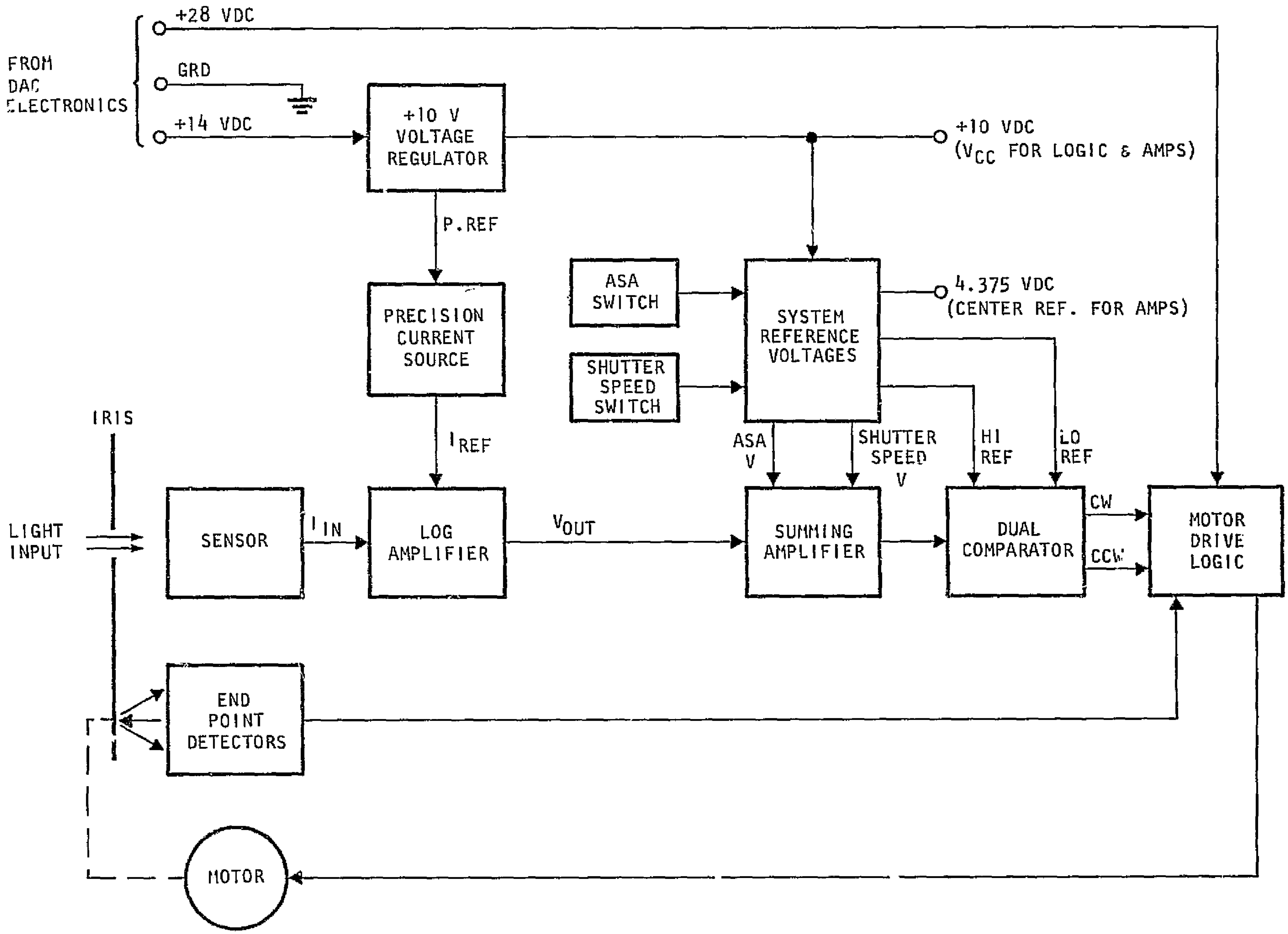



FIGURE 3-1. System Electronics Block Diagram

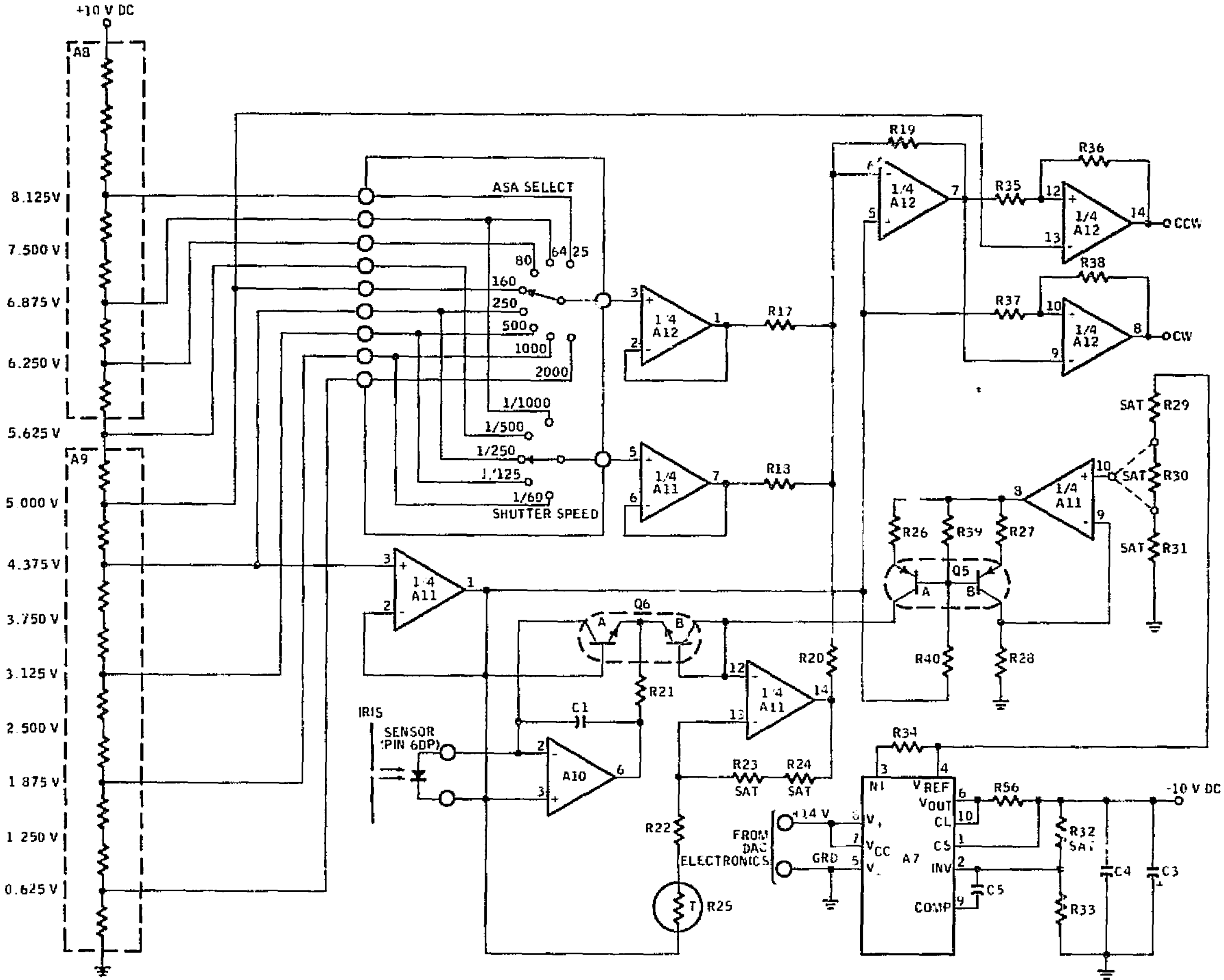



FIGURE 3-2. AEIC Analog Circuit

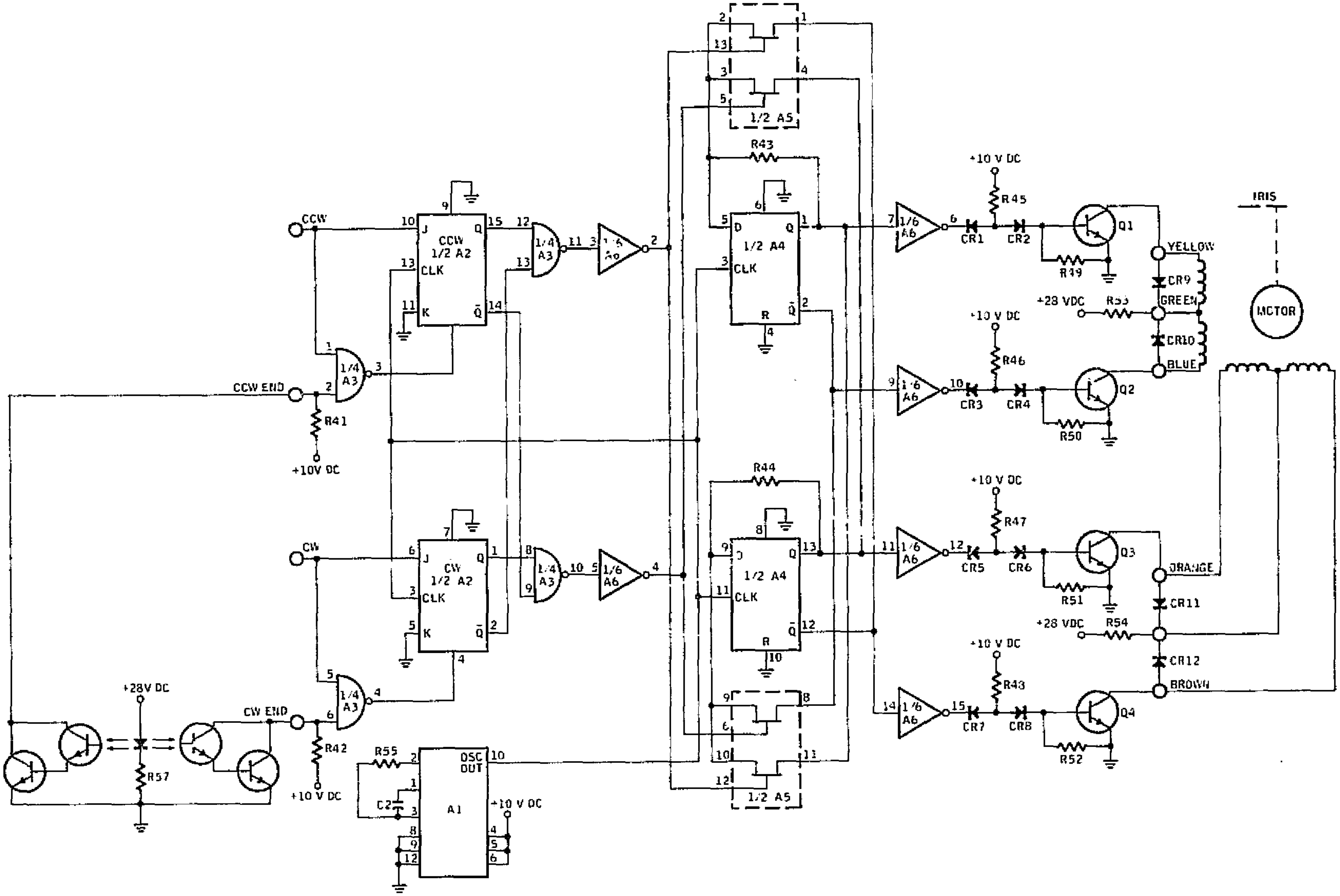



FIGURE 3-3. AEIC Digital Circuit

wires: +28 V dc, +14 V dc and ground. These voltages are picked off at points Q3-C, Q3-E and Q8-E respectively. The AEC draws power only when the camera trigger is activated.

The operation of the system is based on establishing an initial null point for a given set of conditions. This null point coincides with a setting of ASA 250, a shutter speed of 1/250 second, an iris opening of f/5.6, and a light level of 220.8 fL for ideal exposure.

Through the use of a beamsplitter cube, a fixed percentage ($\leq$ 10%) of the light energy passing through the lens is transferred to a planar diffused silicon sensor causing current to flow within the sensor in direct proportion to the input light level. The sensor current is applied to the input of a logarithmic amplifier. A precision reference current is also applied to this amplifier and the output voltage takes the following form:

$$V_{OUT} = \frac{-kT}{q} \ln \frac{I_{in}}{I_{ref}}$$

By adjusting the reference current 1/4 stop below the input current level, a voltage is developed at the output of the log amp which allows the system null point to be set in the center of a defined deadband; i.e., $\pm$1/4 stop. The logarithmetic amplifier stage is followed by a non-inverting amplifier, which prevents excessive loading of the log amp output, as well as providing a gain stage, which allows temperature compensation of the logging element.

The +10 V regulator shown in Figure 3-1 receives a 14 V dc input from the camera electronics. The regulator provides a stable +10 V dc output which is used as the $V_{CC}$ for the amplifiers and the logic. The regulator also provides the +10 V dc for the Reference Voltage Generator and a precision +7.15 reference for the Precision Current Source.

The Reference Voltage Generator consists of two monolothic resistor networks each containing nine resistors of identical value. By applying a +10 V dc reference to this series resistor network, precision reference voltages are provided in 1/2 stop increments. The required voltages are routed through the ASA and Shutter Speed switches to their respective non-inverting followers to provide the null reference levels for a particular set of conditions. This in turn defines the eight stop light band over which the iris compensates for a given ASA and Shutter Speed selection. For the previously stated set of conditions, i.e., ASA 250, a 1/250 shutter speed and an iris opening of f/5.6, the compensation range is 15 to 3534 fL. If an ASA of 500 were selected, the compensation range is from 7.5 to 1767 fL, etc.

The actual comparison is accomplished by combining the output of the ASA amplifier, the shutter speed amplifier and the log amplifier in a summing amplifier. The output of the summing amplifier is then routed to a dual comparator circuit. The dual comparator has as its other inputs, a $\pm$1/4 stop

deadband, centered +1/4 stop above the system center reference of 4.375 V dc. If the ASA setting, shutter speed setting and iris opening have achieved a null condition relative to the ambient light level transmitted to the sensor, the output of the summing amplifier is then in the center of the deadband. Thus, a 1/4 stop change in either direction trips the respective comparator.

The output of the comparators is routed to the Motor Drive Logic. This circuitry develops the correct signal phasing for a bi-directional 90° stepping motor as shown in the timing diagram, Figure 3-4. The stepping motor is mechanically linked to the iris, and thus provides the means for nulling the system, that is, since the sensor is located behind the iris, the iris acts as the feedback element. The particular comparator tripped defines the direction in which the iris must move to compensate for an ambient light level change. Once the motor begins to move, it steps in 1/4 stop increments at a 10 Hz rate until a null is again achieved relative to the light level present. Electrical end points of the iris are detected by an optical sensor and light emitting diode arrangement. These points coincide with the iris extremes of f/1.4 and f/22 and are slightly inside the mechanical stops. When the iris reaches either extreme, the respective detector provides a signal which disables the logic drive and prevents the motor from being further driven in that direction.

## 3.2 TEMPERATURE ANALYSIS

The Space Shuttle camera is designed to operate in the temperature range from -55°C to +85°C. However, while operating, the temperature within the camera rises above the ambient temperature due to the power dissipated by the electronic components within the camera. This internal temperature rise is assumed to be typically 15°C above the ambient temperature. Therefore, the electronics are designed to operate within a temperature range from -55°C to +100°C. In order to maintain system accuracy throughout this wide dynamic temperature range, temperature stable or temperature tracking components have been selected. Also, when needed, temperature compensation circuits have been designed to counteract temperature effects on component parameters.

The system design goals dictate that the analog circuitry be provided with a temperature stable reference voltage from which the analogous ASA and shutter voltages are derived. These reference voltages are also utilized to generate stable bias currents for the logarithmic amplifier. An integrated circuit voltage regulator (LM723H) was chosen to provide the temperature stable reference voltage.

The ASA shutter voltages, mentioned above, are derived with a voltage divider resistor string. The absolute resistance value of each resistor within this string is of very little concern. The important characteristics of the resistor string, are the initial resistance ratios between the individual resistors, and how well these ratios are maintained throughout the temperature range of operation. Also, the resistors must be located in close proximity to each other to ensure that all the resistors maintain the same temperature.

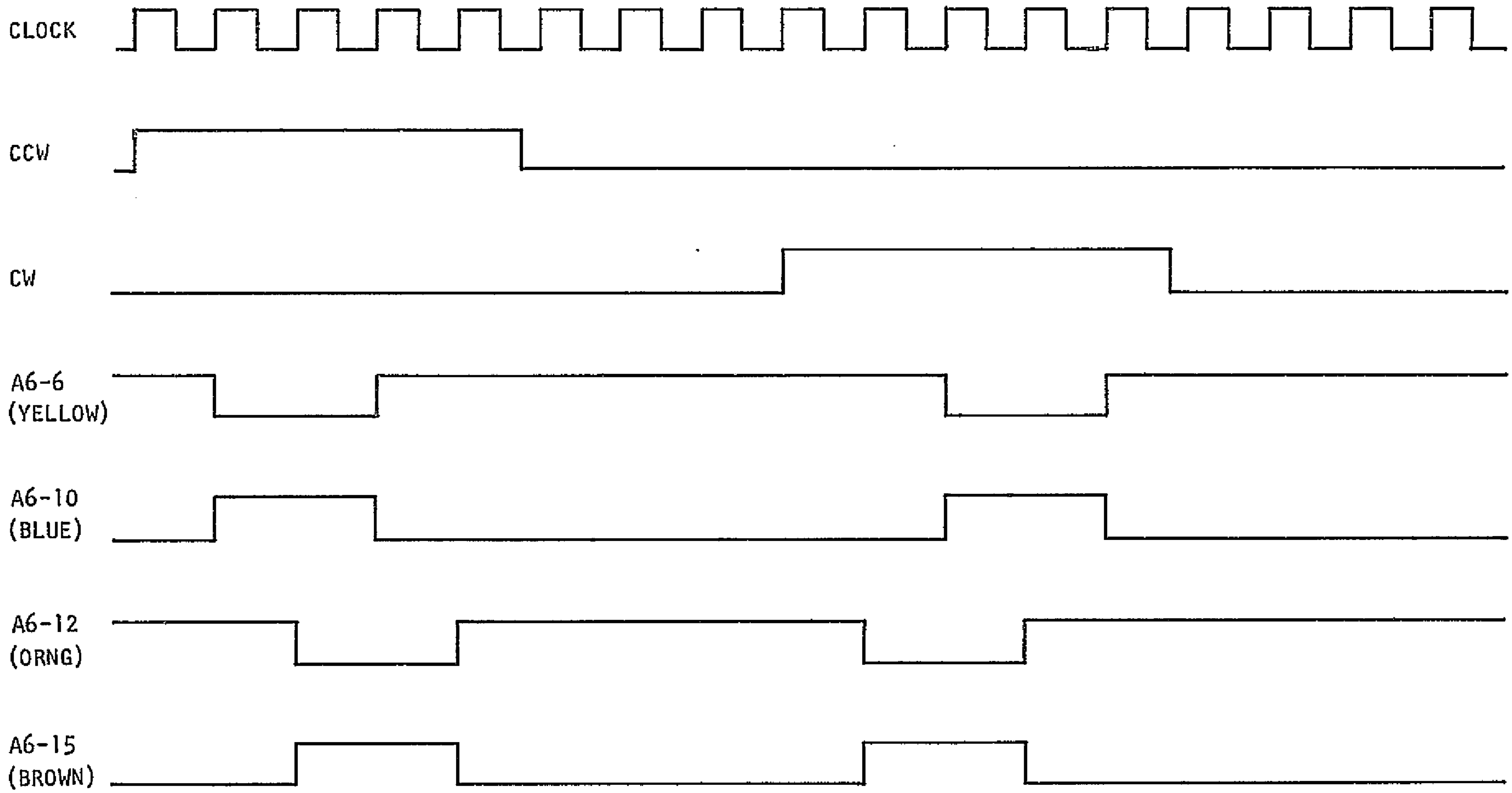



FIGURE 3-4. Signal Phasing for Bi-Directional Motor Drive

To satisfy the above requirements, thin film resistors packaged in two, 14-pin, dual-in-line packages were chosen.

A portion of the analog circuitry, which is very sensitive to temperature variation, is the logarithmic amplifier. The input current signal level is assumed to be centered around $1 \times 10^{-7}$ amperes. To operate on these low signal current levels, an operational amplifier with very low input bias currents is required. Also, the input bias currents of the operational amplifier must be a very small percentage of the signal current at the temperature extremes. Therefore, a high quality, F.E.T. input operational amplifier, with very low input bias currents, was chosen to operate on the input signal currents. Because the input bias current approximately doubles for every 10°C increase in temperature, the initial input bias current at room temperature must be extremely small.

The output signal of the logarithmic amplifier is also a function of temperature. For a given input current signal level, the output voltage of the logarithmic amplifier has a positive temperature coefficient of 0.33%/°C. This effect is compensated for with a temperature dependent resistor (R25) in the feedback loop of the gain stage following the logarithmic amplifier. The temperature dependent resistor has a temperature coefficient of +0.55%/°C. A resistor was added in series with this resistor to reduce the temperature coefficient of the total resistor combination to +0.33%/°C. The temperature dependent resistor causes the gain stage to have a T.C. of -0.33%/°C which counteracts the +0.33%/°C temperature coefficient of the logarithmic amplifier. Thus with a given input current level, the output of the gain stage remains constant with temperature variations.

## 3.3 PARTS SELECTION

In selection of the parts utilized in the electronic design, consideration has been given to several different requirements. These requirements are discussed below, along with specific examples of selected parts.

a. Reliability Level. Whenever possible, parts which meet MIL-STD-883B have been selected. The operational amplifiers/883B, and COS/MOS/3 parts as well as MIL-ER type resistors, capacitors, etc., have specifically been chosen along these lines.

b. Temperature Range. The required operating temperature range has dictated the selection of all parts from both an accuracy and operating standpoint. Specific consideration given to temperature is discussed in the Temperature Analysis Section.

c. Power Consumption. To hold power consumption to a minimum, parts which draw an absolute minimum current have been chosen. Examples of these are the selection of the digital components, i.e., COS/MOS and the low power quad operational amplifier, LM124.

d. Input Voltage. Since the primary input voltage is a positive voltage, amplifiers such as the LM124 and LH0052 have been chosen because they operate off a single positive supply. This eliminates the need for a DC/DC converter, i.e., ± supply voltage.

e. Packaging Constraints. Minimum package size has been a primary consideration in the overall design. Flat packs, dual and quad IC's, CK05, 06 capacitors, etc., have been used whenever practical.

f. Parts Cost. Where a part has been selected which does not have vendor 883B reliability level already established, costs are very high for small quantity orders. In these situations, a temperature rated part without 883B qualifications has been selected. Any tests which are felt necessary to increase the reliability will be performed in house. Effort will continue to find equivalent replacements which have "off-the-shelf" 883B level qualification.

## 3.4 POWER ESTIMATE

The AEC derives its power from the existing camera electronics. It is provided with a nominal +14.3 volts and a nominal +28 volts. The +14.3 volt supply provides power to the AEC analog and digital electronics and the current is not effected by variations in the +14.3 volt output voltage. The +28 volt supply provides power to the iris stepper motor and the current varies directly with the supply voltage.

The first estimate for power requirements of the AEC shows that a maximum of 20 milliamperes will be drawn from the +14.3 volt supply. Twelve milliamperes maximum are required to drive the analog circuitry with the remainder of the current going to the stepper motor drive circuitry and the iris end point sensors. The current drawn by the digital circuit is negligible.

A maximum of 65.5 milliamperes is drawn from the +28 volt supply at 25°C. This maximum current is drawn when the +28 volt line is high, +32 volts.

The AEC represents a total load of 85.5 milliamperes at a line voltage of 32 V which is equivalent to 2.74 watts. Also of importance is the additional power that is dissipated by the +14.3 volt regulator series pass element in the camera electronics. The additional AEC load current causes the series pass element to dissipate an additional 360 milliwatts of power.

## 3.5 ELECTRONIC BREADBOARD TESTING

Present plans call for a verification of the electronic design by testing a breadboard over the desired temperature range. This will be accomplished without sensor or iris interface by simulating the expected current flow produced by the sensor for a given light level. By adjusting the current in fixed increments above or below null, and by providing a corresponding cancellation effect utilizing the ASA and shutter speed settings, the entire electronic subsystem can be verified.

To determine overall system accuracy, a breadboard test of the sensor, iris and optical assembly can also be made. This would provide valuable information on the sensor and/or optical sensitivity relative to temperature variations.

# 4. MECHANICAL DESIGN

The objectives of the mechanical design are to provide an integrated modification package for the existing 16 mm Data Acquisition Camera (DAC), which provides Automatic Exposure Iris Control (AEIC). To this end, this modification design package must meet the following requirements.

a. It will be self contained, consisting of an add on to the existing camera, with minimum modification to existing camera parts.

b. The AEIC will utilize through-the-lens light sensing.

c. The AEIC will add a minimum weight and be held to the smallest size.

d. The AEIC will not degrade performance of the existing camera.

e. The design will use to the maximum extent possible, the technology developed in previous studies.

## 4.1 SYSTEM PACKAGE

The Automatic Exposure Iris Control system is packaged in a aluminum enclosure, which fastens to the front surface of the camera making use of the existing tapped holes.

The front cover of the DAC is removed, and the two sides are milled off leaving a part which supports the aperture plate as shown in Figure 4-1. A small part of the bottom section of this plate is also removed to allow the light bundle from the beamsplitter cube to reach without any vignetting the planar diffused silicon photodiode.

The manual shutter speed switch is modified to include the rotary switch for speed compensation as described in Section 4.3.

The necessary wiring connections to be added to the DAC for operation of the AEIC are +28 V dc to point Q3-C, ground to point Q8-E, and +14 V dc to point Q3-E as indicated in Figure 4-2.

The three wires are routed from the connecting points through the wire hole in the front of the camera to the electronic module.

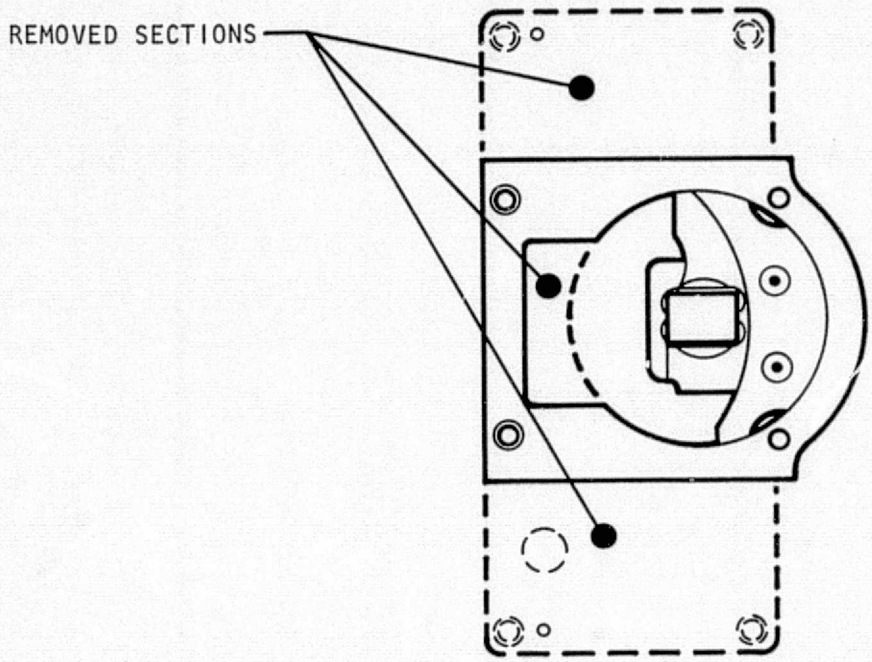





FIGURE 4-1

Cover Plate Modification

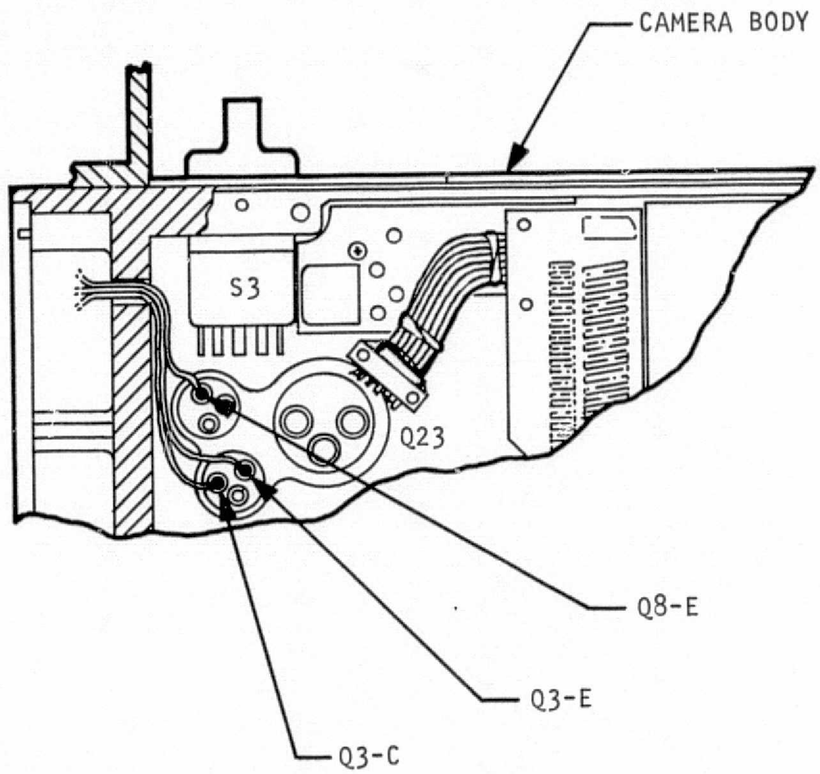



FIGURE 4-2

Camera Wiring Installation

The modified front cover and aperture plate are reinstalled on the camera using two of the four available screw holes. The AEIC enclosure is then installed over the modified cover, completely covering the camera front, with the remaining six mounting screws.

The AEIC enclosure has two cover plates, one for access to the stepper motor and gears, and one for access to the electronic module. All the electronics are fastened to the cover as shown in Figure 4-3. This method of manufacture allows the removal, inspection and/or repair of the electronics without the need for disconnecting or cutting of wires.

The electronic package design utilizes a combination of welded wire modules, potted stick modules and conventional printed circuit board techniques. The motor drive logic and summing amplifier circuits are packaged into two stick modules, constructed by using laminated nickel interconnects and epoxy substrates onto which flatpacks or components are welded and in turn each stick is rigidly potted in epoxy. The motor drive, 20 V regulator and log amp circuits are packaged in conventional welded modules.

The stick modules are bonded, and the welded modules are soldered to a printed wiring board, which in turn provides most of the interconnects between modules, module sticks and switches. The ASA/Shutter reference string and select resistors are mounted to a small additional printed wiring board. This complete electronic assembly, as indicated before, is mounted to the cover with four threaded spacers.

We feel that this design is structural sound, and at this time no additional potting of this module is anticipated.

The lens is assembled to the AEIC enclosure with three screws through the mounting flange. Locating marks on the iris ring gear, flange and drive gear facilitate ease of removal and installation.

## 4.2 IRIS DRIVE MECHANISM

The basic concepts of the iris drive system are shown in Figure 4-4. Since the iris itself, is designed with a linear relationship between angular adjustment motion and f-stop increments, the iris drive requires no more than a straight gear reduction between the stepper motor and the iris ring on the lens.

This reduction is accomplished in two stages. The first stage utilizes a gear ratio of 5 to 1 through the use of the 13 tooth pinion cut on the shaft of the stepper motor and a 65 tooth gear. The pinion and first gear use a 120 pitch. A courser pitch of 64 was selected for the second stage with a ratio of 6.47/1 cutting 17 on the second gear, and 110 teeth on the iris ring gear. The courser pitch was selected to facilitate installation and removal of lenses, without damaging the gear teeth. The overall gear ratio is 32.36 which coincides with 32 steps of 90° on the stepper motor, and 89° rotation on the iris ring. Every step of 90° on the stepper motor is equivalent to a 1/4 f-stop adjustment on the lens iris.

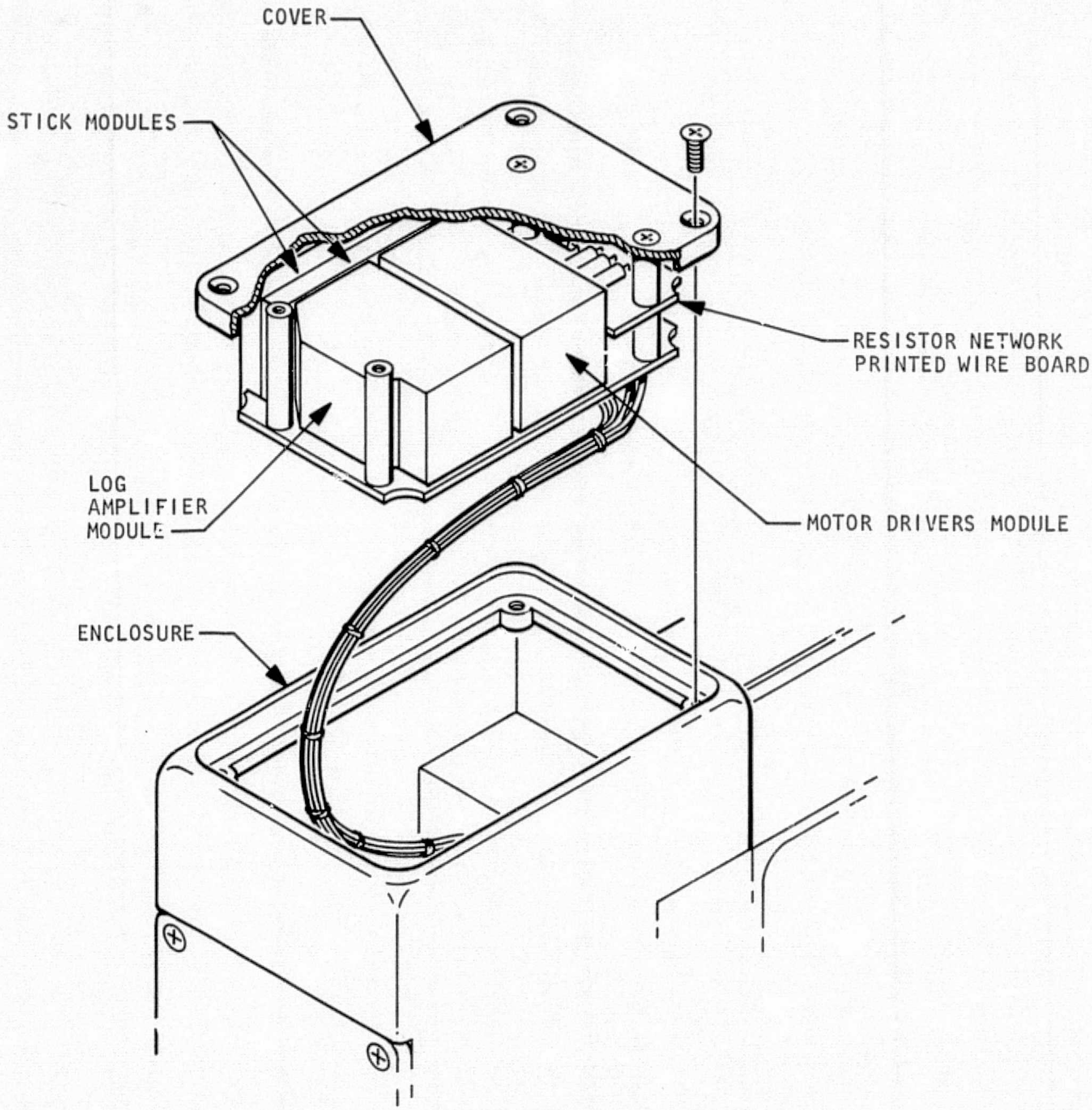



FIGURE 4-3

Electronic Module Assembly Installation

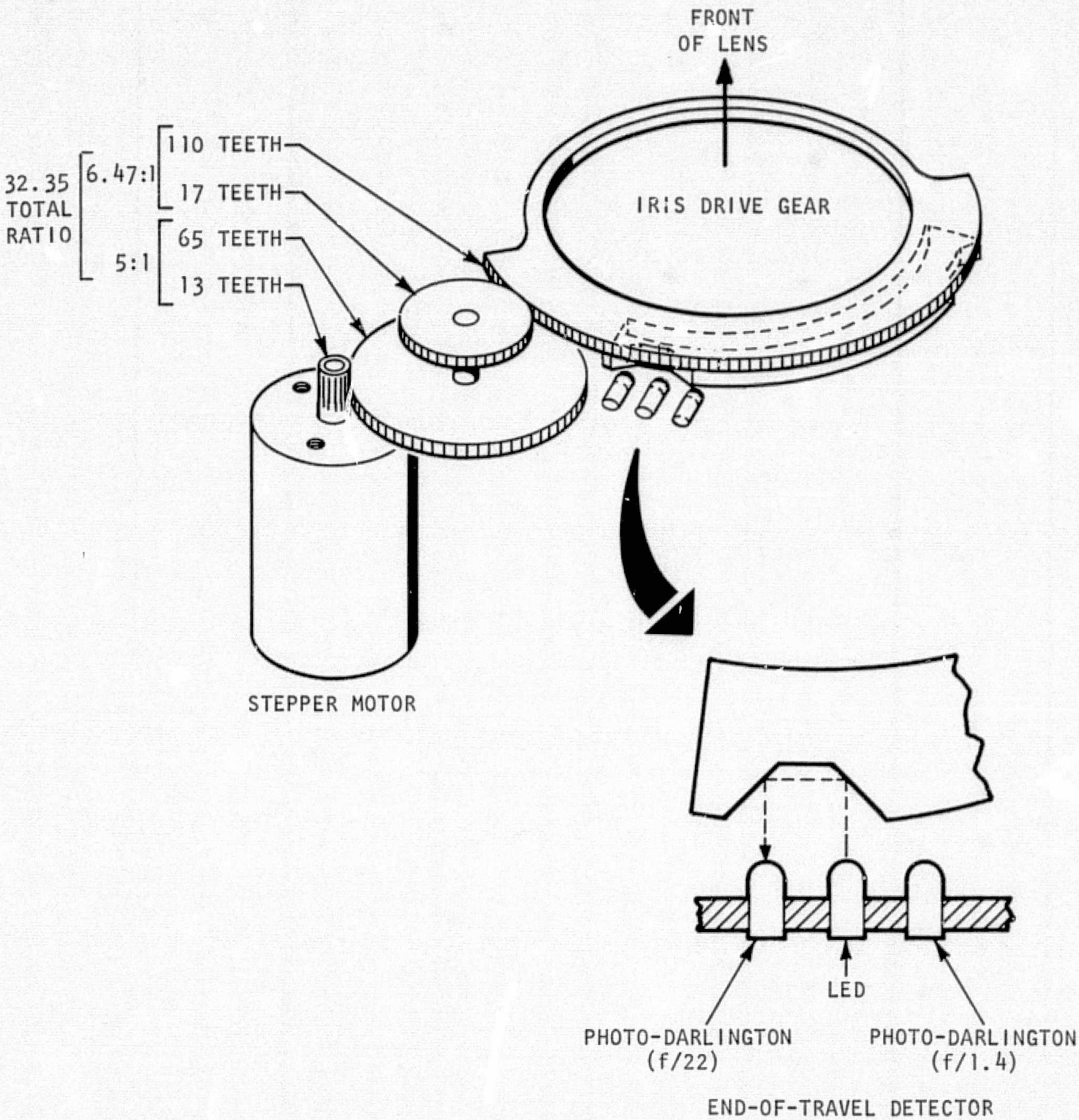



FIGURE 4-4

Iris Drive System

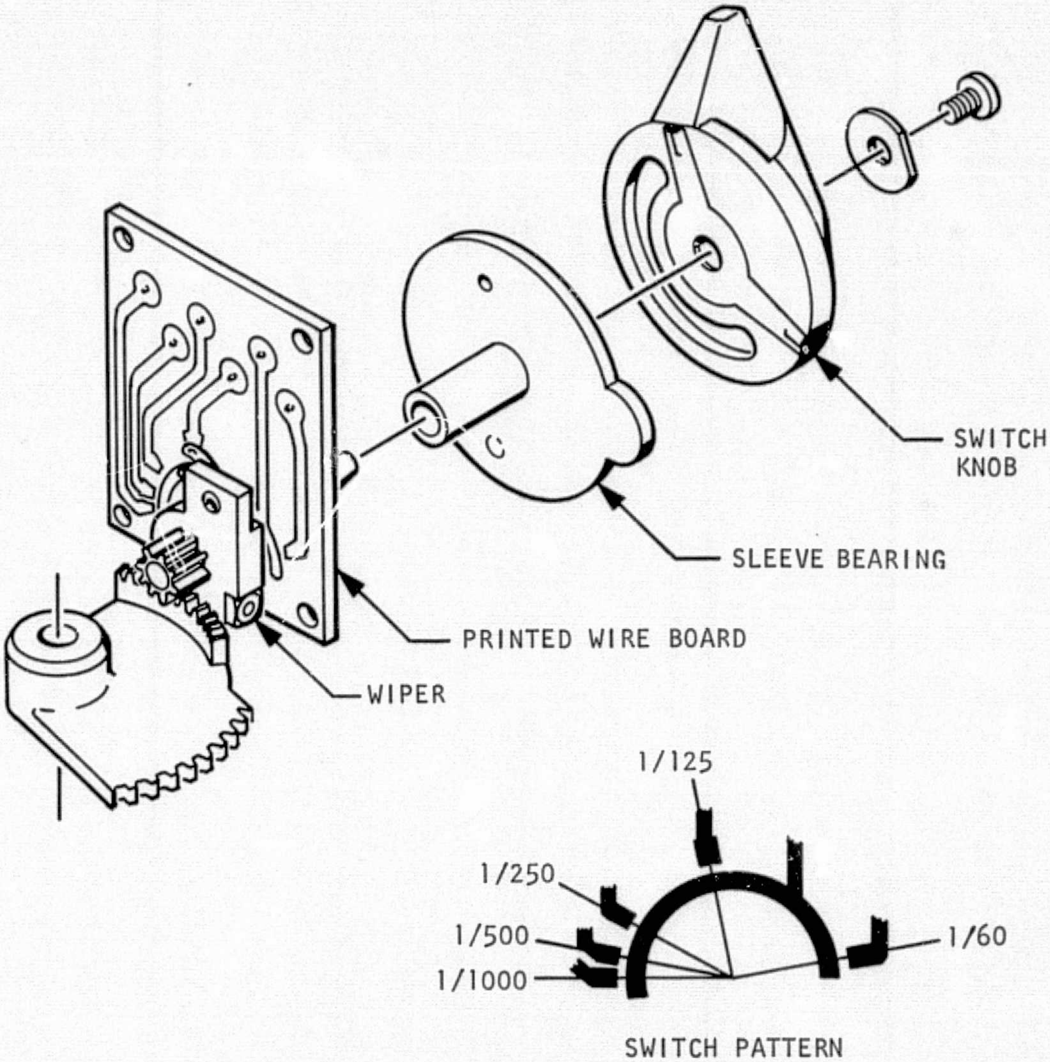



FIGURE 4-5

Shutter Speed Compensation Switch

The material for the gears is aluminum, plated with a hardcoat of chrome alloy called electrolizing. The thickness of this coat does not exceed 0.0002 inch, yet tests on these gears have accumulated more than 2,000 hours, showing no wear whatsoever. The bearings used will be Barden, nonlubricated, ball bearings.

## 4.3 SHUTTER SPEED COMPENSATION SWITCH

As detailed in the Electronic Design Section, this switch is designed to compensate the iris operation for equivalent step changes in the shutter speeds. To avoid the requirement for technicians to set an extra switch for iris change after a change in shutter speed selection, a special switch, shown in Figure 4-5 was designed as part of the shutter speed adjustment mechanism of the DAC. The stationary part of the switch, incorporating five contacts corresponding to the equivalent five shutter settings, is provided on a printed circuit board. The The contact points are rhodium plated for wear resistance, and are spaced in accordance with the existing detent pattern of the shutter speed knob.

Separate wiper arms for the continuous intermittent contacts assure that good contact will be made at all times. The switch addition is designed to require an absolute minimum of camera modification.

## 4.4 IRIS END OF TRAVEL DETECTORS

Light sensing was selected as the simplest, and most reliable method to provide individual signals for indication of both extreme sides of the iris travel, as required by the electronic logic. Figure 4-4 illustrates the use of a single light emitting diode used together with two light reflecting V-blocks, made of clear anodized aluminum and mounted to the bottom side of the iris gear ring for illumination of two separate darlingtons. The combination of the LED and one darlington will indicate separate signals for each end of the iris travel, thus reducing the power requirement.

## 4.5 WEIGHT ESTIMATE

The estimated weight for the addition of the Automatic Exposure Iris Control in accordance with the indicated design is approximately 33 ounces.

This total weight is distributed according to the following estimates:

a. Lens 24 oz

b. Mechanical 6.5 oz

c. Electronics 2.5 oz

# 5. OPTICAL DESIGN

The objective of the optical design was to provide a lens with the capabilities as good as or better than the requirements set forth in Specification CF 32A-701 from NASA (JSC) while at the same time, incorporating a number of additional features to make the lens compatible with the Automatic Exposure Iris Control system.

The primary optical requirements of Specification CF 32A-701 were:

a. Distortion shall produce less than 0.002 inch error in straightness in the image of a straight line anywhere within the format.

b. Transmittance shall be greater than 80% in the wavelength range of 435 to 650 nanometers.

c. The relative illumination shall be 25% at 90% of the full field.

d. The equivalent focal length shall be 10.2 mm.

e. The field of view shall be 65°.

The detailed specification in regard to aberrations and visual resolution was discussed with NASA and it was agreed that data measured and derived from the existing 10 mm lens could be used as a basis for the new lens image quality evaluation. Figure 5-1 shows the Modulation Transfer Function (MTF) of the existing lens measured up to 100 line pairs/mm. Beyond this point the data was extrapolated as is typical for lenses of this type.

Figure 5-1 includes only axial MTF data, as off-axis measurements on a wide-angle lens of this type require special tooling in order to be valid, and neither time nor money permitted design and manufacture of this tooling. The MTF data of Figure 5-1 were used in conjunction with the ratio between on-axis and AWAR performance of Specification CF 32A-701 to give proper weight to the off-axis MTFs obtained in the design, thus insuring that the overall performance of the Perkin-Elmer lens will be satisfactory.

Other requirements imposed on the lens are as follows:

a. Meet or exceed the requirements of lens Specification CF 32-A-701.

b. The maximum aperture shall be f/1.4.

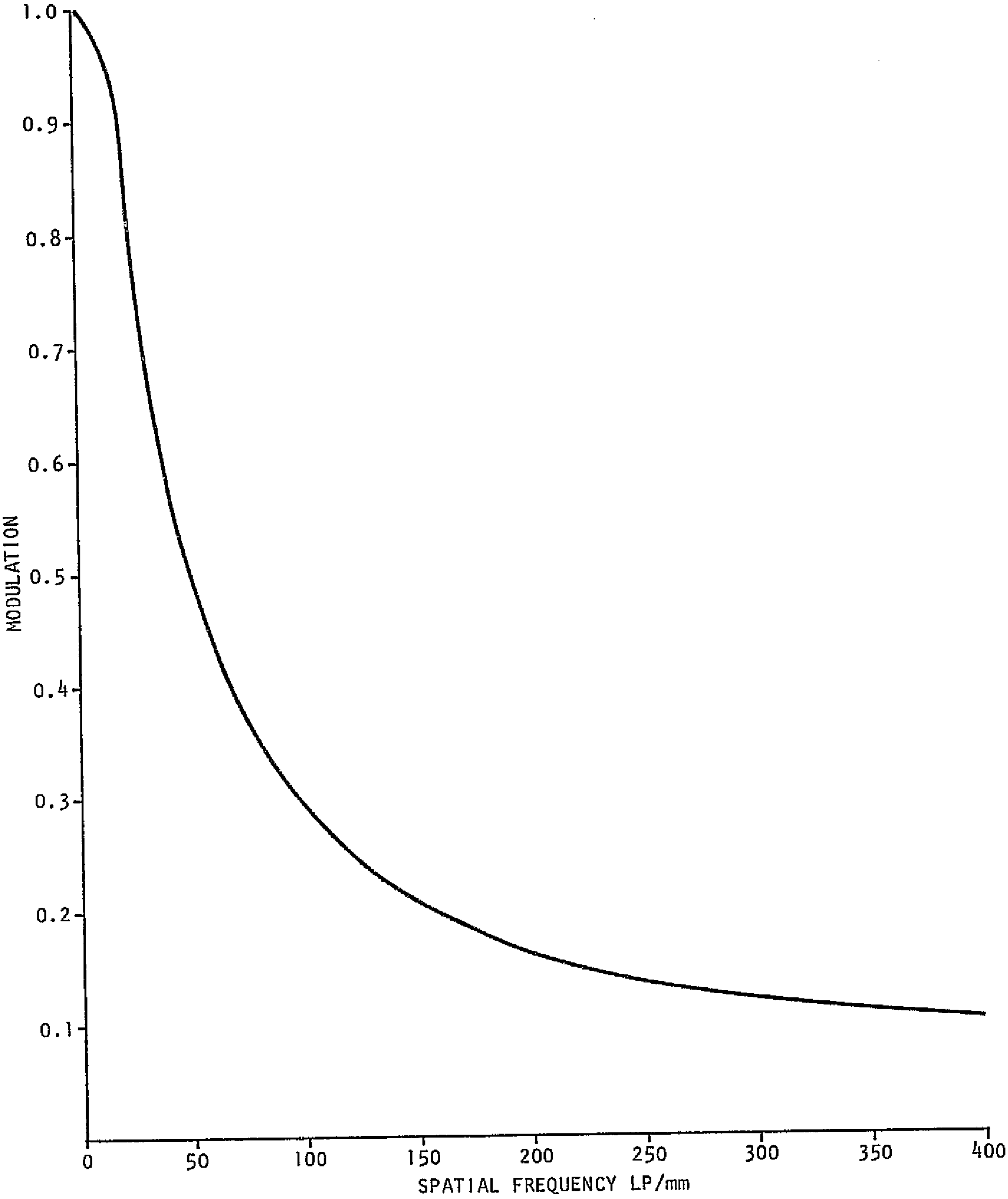



FIGURE 5-1

Axial MTF of NASA Furnished 10mm Lens (AWAR)

c. A beamsplitter shall be incorporated to direct a maximum of 10% of the light from the lens to a planar diffused silicon sensor.

d. Focusing shall be internal, so the overall barrel length does not change as the lens is focused from infinity to 200 mm.

e. A fixed mounting flange.

f. The iris shall be designed so that an equal rotation results in an equal change in aperture ratio at any point in the range from f/1.4-f/22; that is, every f-stop will turn the iris ring gear the same number of degrees.

## 5.1 OPTICAL SYSTEM

All the requirements of Specification CF 32A-701, with modifications and the changes set forth above, have been met by the lens design. Since the iris ring is purely mechanical, and in this case does not affect the space requirements of the optical design, the details will be submitted when the complete lens design is finished.

The maximum aperture ratio of the lens is f/1.4.

The beamsplitter cube incorporated in the design is made of glass rather than a pellicle since the additional glass path reduces the burden for provision of a back focus considerable greater than the lens focal length. Focusing is provided by internally moving the fifth lens element so that the barrel length remains unchanged over the total focusing range. This lens movement is approximately 3 mm for the total focus range of 200 mm to infinity.

With magnesium fluoride coatings, average transmittance over the spectral range from 435 to 650 mm is greater than 80%, although Figure 5-2 shows that at the shorter wavelengths it falls somewhat below that point. If the 80% figure should be interpreted as a minimum transmittance at all wavelengths in the range of interest, some surfaces would need to be coated with multi-layer coatings. Relative illumination is over 60% at the edge of the field, thus being far above specification. We feel that during quantity production all lens elements will be supplied with multi-layer coatings, thus improving the lens transmittance figures.

Equivalent focal length, field of view and f-number are, of course, basic starting points in the design.

Distortion is somewhat more difficult, and in fact in wide-angle retrofocus lenses of this type, distortion is usually very difficult to control without resorting to aspheric surfaces. However, in this case it was possible to meet the requirement of no deviation greater than 0.002 inch from straightness in the image of a straight line. The worst case occurs when the lens is focused at 200 mm and the line is at the edge of the format in the short direction.

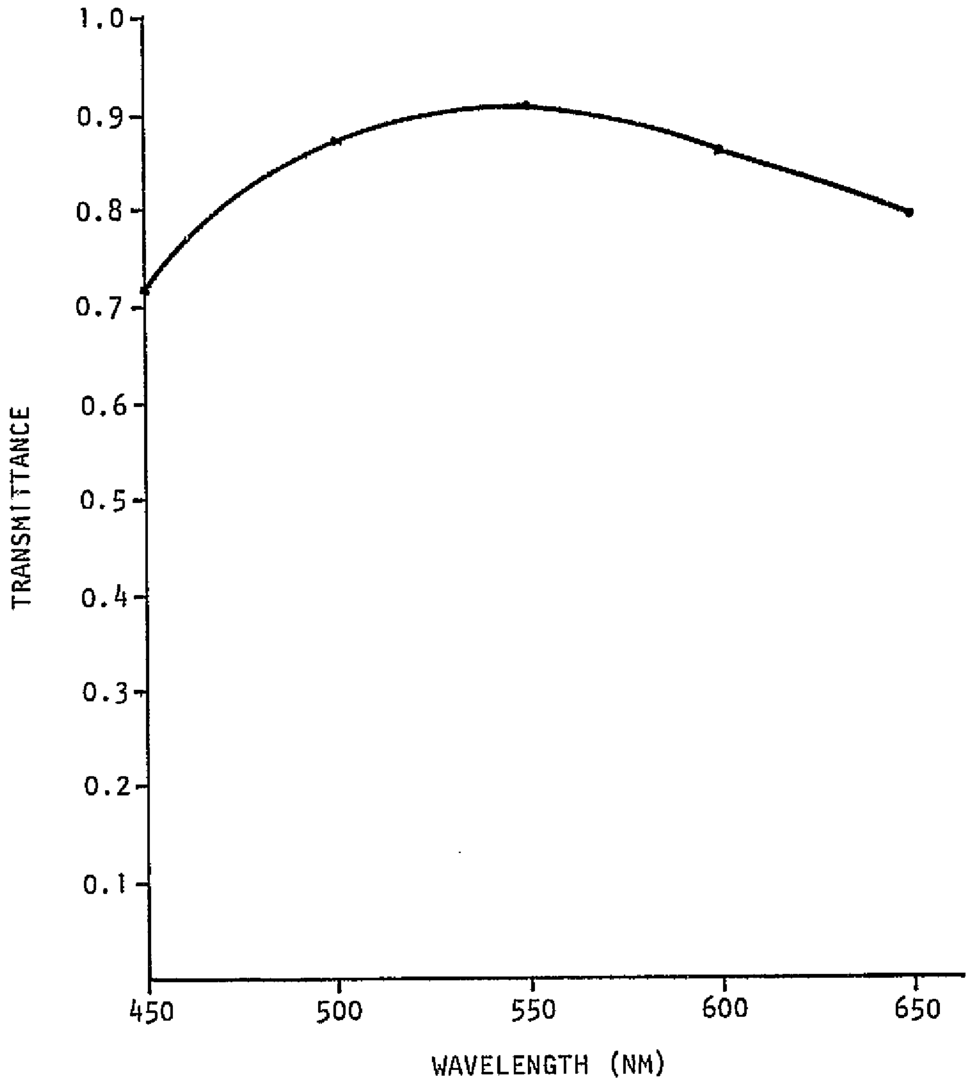



FIGURE 5-2
Spectral Transmittance

In this case, the line deviates from straightness by 0.0018 inch. For lines closer to the center of the field of view, lines parallel to the shorter dimension of the format, and focal positions nearer infinity, the situation improves considerably.

Figure 5-3 shows the modulation transfer function data for the Perkin-Elmer lens at infinity focus, and Figure 5-4 shows the same information for a focal distance of 200 mm. When these curves are compared with the aerial image modulation (AIM) curves of 3414 film, resolution figures of 240 lp/mm on axis and 200 lp/mm AWAR are obtained for infinity focus and 200 lp/mm both on axis and AWAR for 200 mm focal distance.

Resolution tends to be a rather subjective criterion, and varies greatly with different film readers especially when resolution in excess of 100 lp/mm are involved. This is one reason why modulation transfer functions, which can be computed directly for a design and measured directly for its execution, is now very largely replacing resolution as the criterion for lens performance. The resolution measured on either lens may be better or worse than those predicted above from lens MTF data and film AIM curves, but the Perkin-Elmer lens is definitely superior to the existing 10 mm camera lens in any direct comparison.

## 5.2 LENS ASSEMBLY

Figure 5-5 illustrates the entire lens assembly. Only one cemented surface is included, between the third and fourth elements. Since the first three elements are of dense flint glasses, no ultraviolet at shorter wavelengths than 360 nm will ever reach the cement, however, during manufacture a cement resistance to discoloration by ultraviolet will be utilized.

Focusing is accomplished by turning the knurled ring which drives the fifth element through a cam. Aperture change, provided automatically through the automatic exposure control system, is driven through an external gear ring which in turn drives the iris by a pin through the lens housing.

The only additional optical component which is not involved in the basic optical design is the field lens, cemented to the upper surface of the beamsplitter cube. This lens does not affect the image-forming light, but serves to image the aperture stop of the lens on the detector for the light-sensing system. This arrangement gives even illumination of the detector for any level variations over the scene, so that the illumination sensed by the detector is an integrated average of the entire field of view.

Additional optical data are supplied in Appendix A.

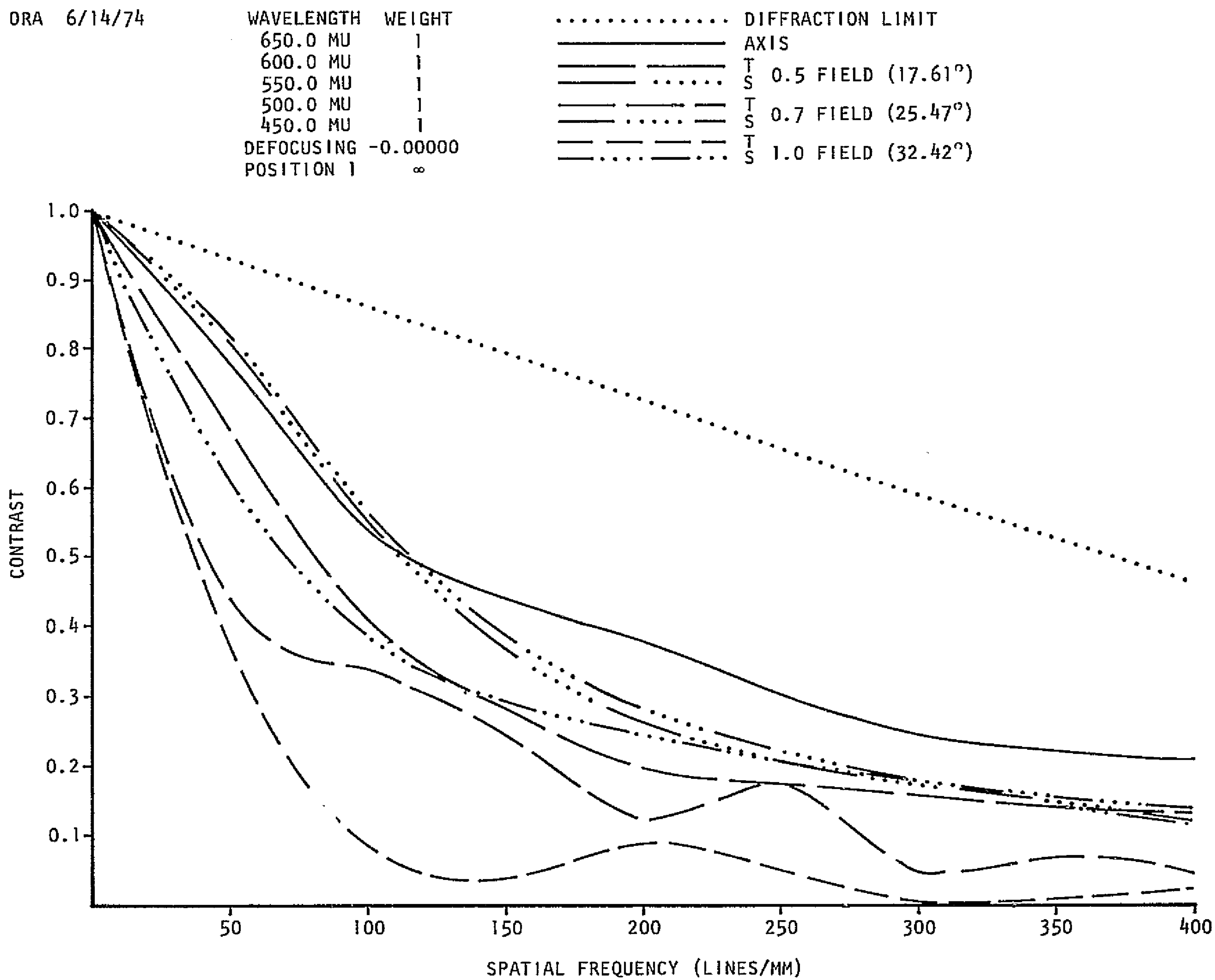



FIGURE 5-3. Modulation Transfer Function at Infinity

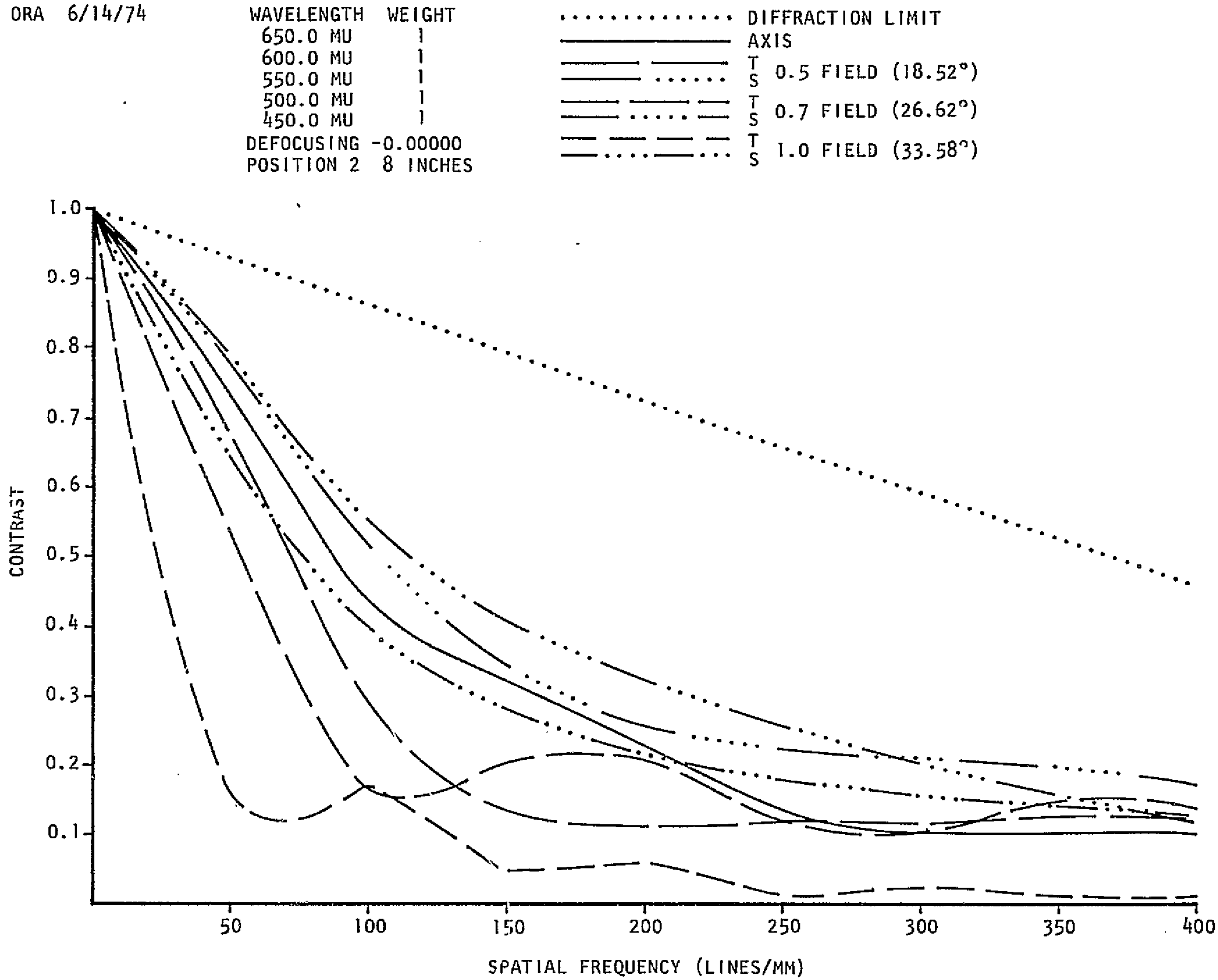



FIGURE 5-4. Modulation Transfer Function at 200 mm

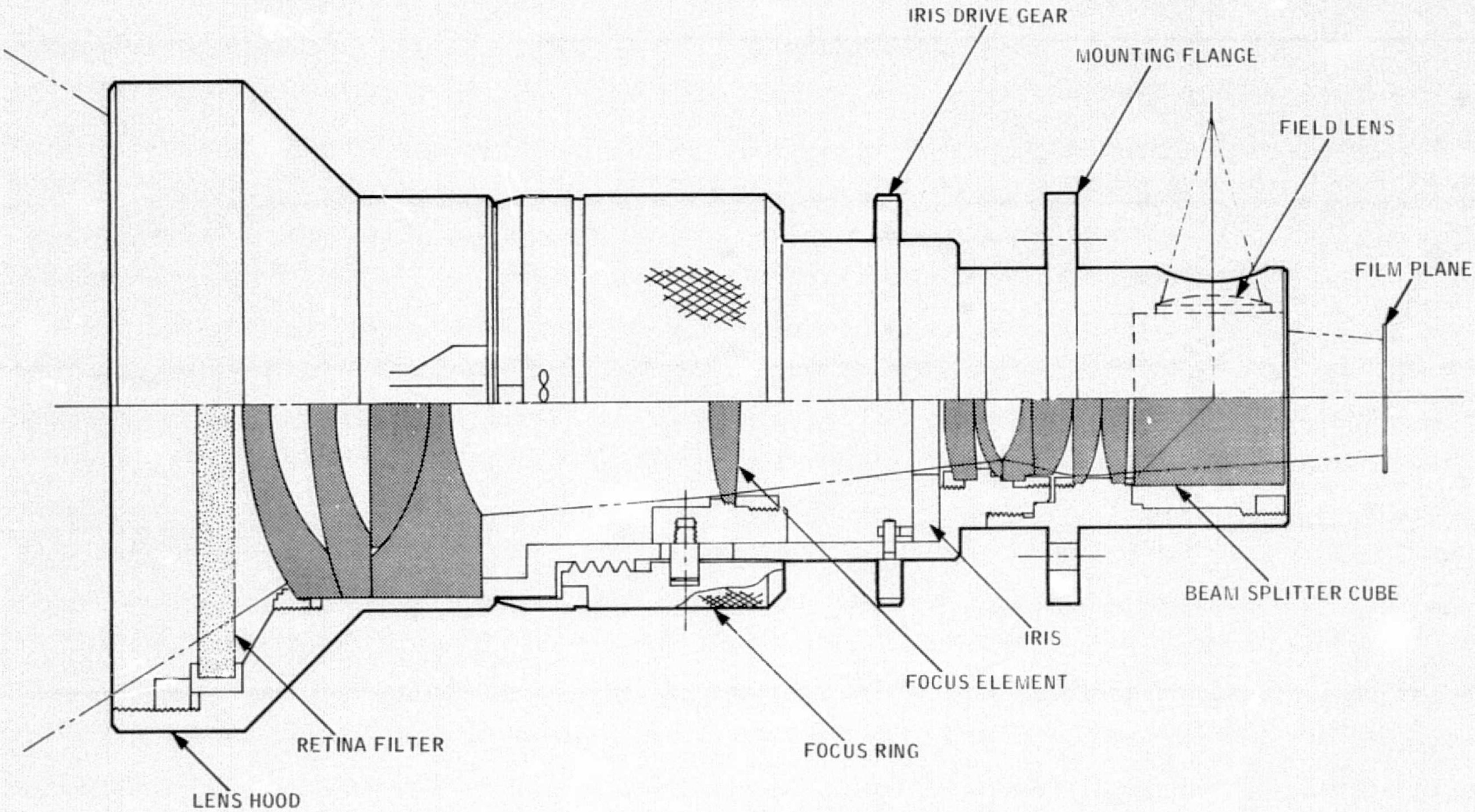



FIGURE 5-5

Camera Lens Assembly

# 6. DESIGN SUMMARY

The primary objective of the Automatic Exposure Iris Control system design is to provide an add-on unit, which can be readily attached to the existing DAC, with minimal modification while meeting the requirements set forth in the Statement of Work and all applicable specifications.

To accomplish this task, the three disciplines of electronics, mechanics and optics were combined to provide a compact, rugged device capable of operating in a space environment, without adding significantly to the weight and size of the existing camera.

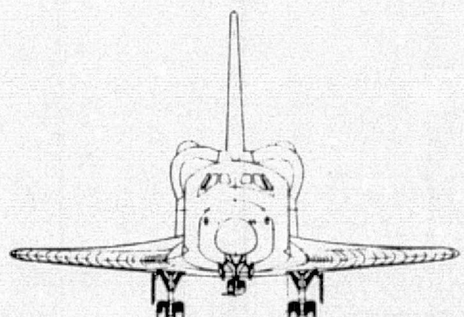
The AEIC system design will compensate over a light range of 0.5 to 120,000 fL (18 stops). This is accomplished by using an ASA compensation range of ASA 25 to ASA 2000 (6 stops) a shutter speed compensation range of 1/60 to 1/1000 of a second (4 stops) and an iris compensation range of f/1.4 to f/22 (8 stops).

The sensing element selected is a planar diffused silicon sensor, which exhibits excellent linearity over a wide range of light energy. To reduce the effective range over which the sensor must operate, and also to provide for optimum exposure, the sensor is mounted behind the lens iris assembly and is exposed to light transmitted from a beamsplitter cube. The overall system design goal is exposure control within ±1/4 stop of ideal relative to a specific ASA, shutter speed, iris opening and ambient light level.

Thorough consideration was given to specific areas of the design relative to various environmental requirements. In the electronics area, primary effort was directed at establishing a design which provides accurate results over temperature extremes. This effort consisted of analysis to determine specific parts, and the addition of temperature compensation circuitry where necessary. The electronic design also provides for compensation for variation of the sensor sensitivity, if it becomes necessary.

The total add-on assembly adds minimal size and weight. Additional power consumed by the electronics is estimated at 2.74 watts based on a line voltage of 32 V dc, and is drawn only when the camera is activated.

# APPENDIX A
# SUPPLEMENTARY OPTICAL DATA



FULL SCALE

POSITION 1
ORA 6/14/74

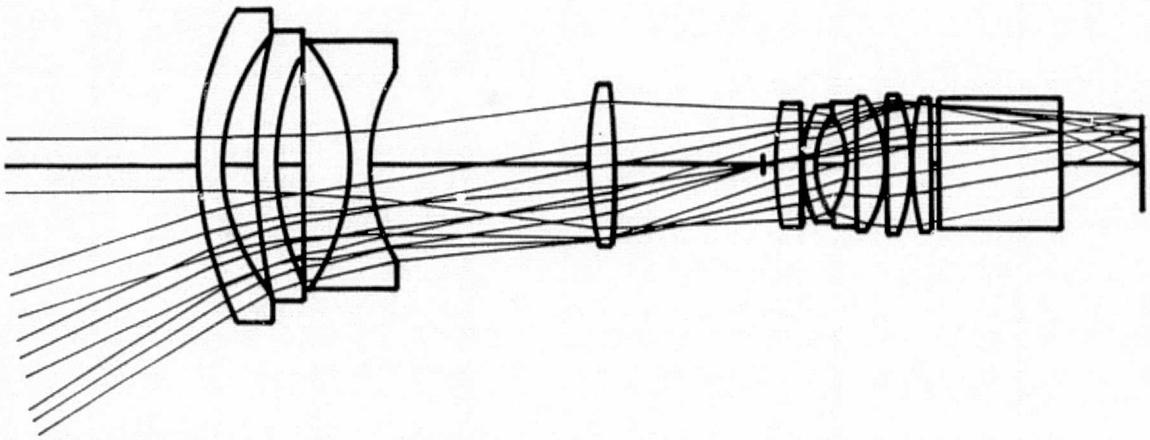


FIGURE A-1

f/1.4, 10 mm W/A Objective at Infinity

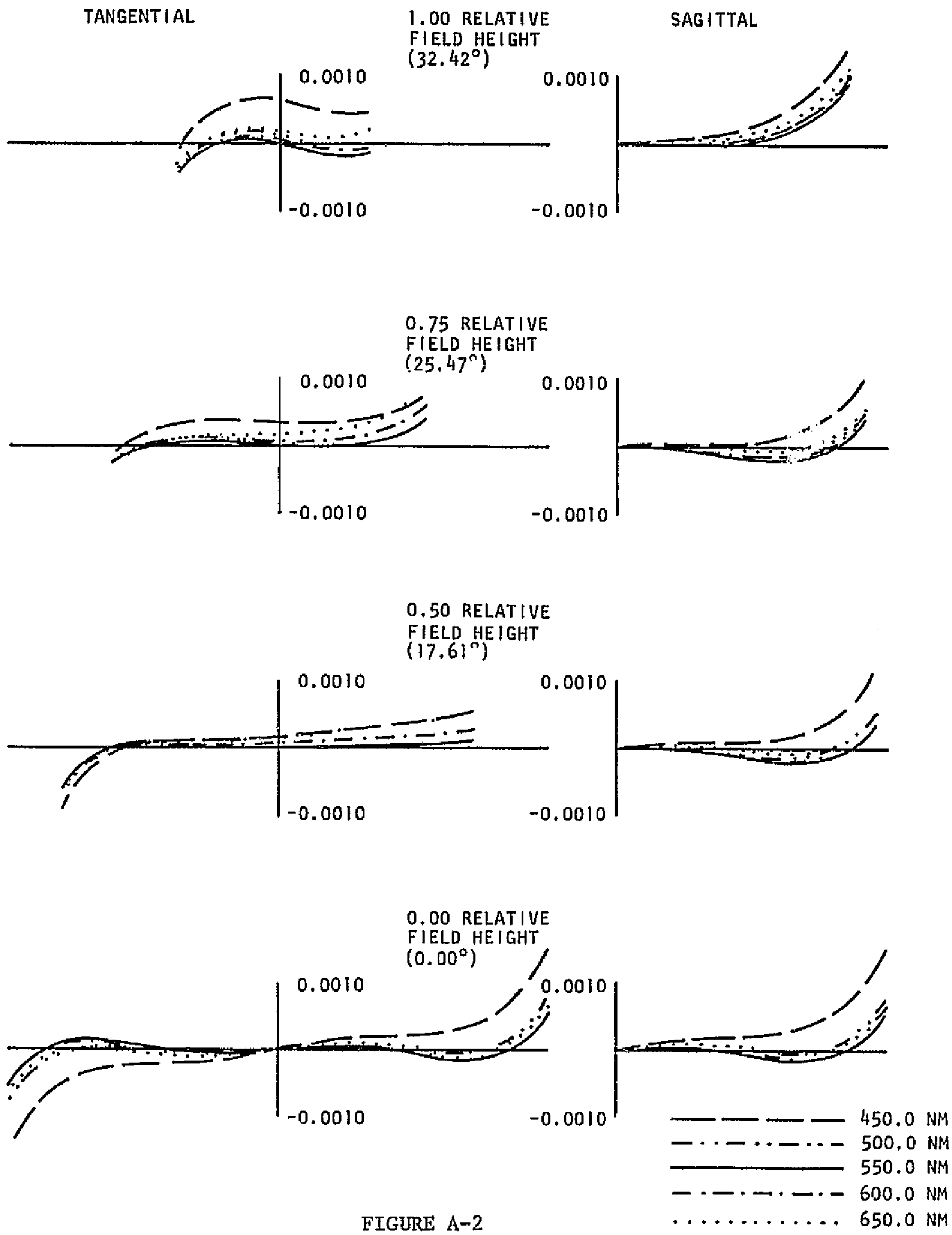



FIGURE A-2

f/1.4 W/A Objective Abberation Plots at Infinity

TABLE A-1

Diffraction MTF at Infinity at 0.00°

POSITION 1          DIFFRACTION MTF          CRA          6/14/74

10MM F/1.4 (AT F/2)    W/A OBJECTIVE          PER-OBJ-063

FIELD POSITION = 0.00 Y MAX. ( 0.00 DEGREES)
RELATIVE ILLUMINATION =100.0 PER CENT
DISTORTION = 0.00 PER CENT

| WAVELENGTH | WEIGHT |
|---|---|
| 650.0 NM | 1 |
| 600.0 NM | 1 |
| 550.0 NM | 1 |
| 500.0 NM | 1 |
| 450.0 NM | 1 |

| | DIFFRACTION LIMIT | | | FOCUS POSITION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F/NO | OBSCURED | | -.00040 | | -.00020 | | -.00000 | | .00020 | | .00040 | |
| L/MM | 2.00 | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN |
| | .999 | .999 | | .999 | | .999 | | .999 | | .999 | | .999 | |
| 50 | .930 | .930 | | .703 | | .753 | | .760 | | .783 | | .763 | |
| 100 | .860 | .860 | | .439 | | .514 | | .537 | | .514 | | .463 | |
| 150 | .791 | .791 | | .282 | | .408 | | .436 | | .381 | | .290 | |
| 200 | .722 | .721 | | .128 | | .292 | | .377 | | .340 | | .231 | |
| 250 | .655 | .653 | | .063 | | .195 | | .301 | | .307 | | .219 | |
| 300 | .588 | .586 | | .047 | | .155 | | .243 | | .259 | | .201 | |
| 350 | .523 | .521 | | .038 | | .140 | | .220 | | .220 | | .169 | |
| 400 | .459 | .456 | | .037 | | .129 | | .207 | | .191 | | .127 | |
| 450 | .398 | .396 | | .048 | | .128 | | .195 | | .166 | | .089 | |

TABLE A-2

Diffraction MTF at Infinity at 17.61°

POSITION 1 DIFFRACTION MTF ORA 6/14/74

10MM F/1.4 (AT F/2) W/A OBJECTIVE PER-OBJ-063

FIELD POSITION = .50 Y MAX. ( 17.61 DEGREES)
RELATIVE ILLUMINATION =104.5 PER CENT
DISTORTION = -1.15 PER CENT

| WAVELENGTH | WEIGHT |
|---|---|
| 650.0 NM | 1 |
| 600.0 NM | 1 |
| 550.0 NM | 1 |
| 500.0 NM | 1 |
| 450.0 NM | 1 |

| | DIFFRACTION LIMIT | | | FOCUS POSITION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F/NO | OBSCURED | | -.00040 | | -.00020 | | -.00000 | | .00020 | | .00040 | |
| L/MM | 2.00 | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN |
| | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 |
| 50 | .930 | .934 | .929 | .817 | .576 | .824 | .638 | .808 | .684 | .765 | .712 | .712 | .717 |
| 100 | .860 | .868 | .858 | .598 | .347 | .592 | .399 | .549 | .405 | .483 | .365 | .408 | .301 |
| 150 | .791 | .803 | .788 | .473 | .219 | .435 | .283 | .366 | .283 | .308 | .187 | .276 | .025 |
| 200 | .722 | .737 | .719 | .413 | .165 | .355 | .214 | .261 | .194 | .207 | .098 | .207 | .086 |
| 250 | .655 | .672 | .652 | .369 | .120 | .315 | .179 | .205 | .173 | .141 | .097 | .151 | .079 |
| 300 | .588 | .607 | .585 | .323 | .088 | .282 | .146 | .172 | .156 | .095 | .082 | .102 | .010 |
| 350 | .523 | .546 | .520 | .284 | .067 | .247 | .122 | .146 | .139 | .066 | .053 | .066 | .085 |
| 400 | .459 | .485 | .456 | .253 | .056 | .207 | .103 | .118 | .131 | .044 | .071 | .040 | .132 |
| 450 | .398 | .426 | .395 | .227 | .045 | .168 | .093 | .088 | .134 | .028 | .106 | .024 | .126 |

## TABLE A-3

Diffraction MTF at Infinity at 25.47°

POSITION 1 DIFFRACTION MTF ORA 6/14/74

10MM F/1.4 (AT F/2) W/A OBJECTIVE PFR-OBJ-063

FIELD POSITION = .75 Y MAX. ( 25.47 DEGREES)
RELATIVE ILLUMINATION = 95.3 PER CENT
DISTORTION = -2.04 PER CENT

| WAVELENGTH | WEIGHT |
|---|---|
| 650.0 NM | 1 |
| 600.0 NM | 1 |
| 550.0 NM | 1 |
| 500.0 NM | 1 |
| 450.0 NM | 1 |

| | DIFFRACTION LIMIT | | | FOCUS POSITION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F/NO | OBSCURED | | -.00040 | | -.00020 | | -.00000 | | .00020 | | .00040 | |
| L/MM | 2.00 | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN |
| | .999 | .999 | .999 | .999 | .990 | .999 | .999 | .999 | .999 | .995 | .999 | .999 | .999 |
| 50 | .930 | .940 | .921 | .824 | .371 | .832 | .407 | .816 | .437 | .779 | .461 | .723 | .476 |
| 100 | .860 | .879 | .842 | .616 | .278 | .610 | .216 | .564 | .341 | .490 | .345 | .403 | .323 |
| 150 | .791 | .820 | .762 | .459 | .193 | .434 | .226 | .385 | .246 | .333 | .243 | .286 | .209 |
| 200 | .722 | .760 | .683 | .352 | .105 | .313 | .121 | .282 | .118 | .269 | .094 | .250 | .077 |
| 250 | .655 | .701 | .604 | .285 | .125 | .235 | .159 | .220 | .176 | .232 | .168 | .215 | .138 |
| 300 | .588 | .643 | .525 | .242 | .044 | .184 | .052 | .176 | .046 | .196 | .034 | .177 | .054 |
| 350 | .523 | .584 | .451 | .210 | .041 | .149 | .057 | .141 | .068 | .163 | .070 | .146 | .054 |
| 400 | .459 | .526 | .379 | .183 | .034 | .121 | .042 | .112 | .042 | .133 | .038 | .121 | .041 |
| 450 | .398 | .470 | .308 | .159 | .015 | .101 | .015 | .090 | .003 | .111 | .038 | .105 | .076 |

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TABLE A-4

Diffraction MTF at Infinity at 34.42°

POSITION 1 DIFFRACTION MTF ORA 6/14/74

10MM F/1.4 (AT F/2) W/A OBJECTIVE PER-OBJ-063

FIELD POSITION = 1.00 Y MAX. ( 32.42 DEGREES)
RELATIVE ILLUMINATION = 61.0 PER CENT
DISTORTION = -2.00 PER CENT

| WAVELENGTH | WEIGHT |
|---|---|
| 650.0 NM | 1 |
| 600.0 NM | 1 |
| 550.0 NM | 1 |
| 500.0 NM | 1 |
| 450.0 NM | 1 |

| | DIFFRACTION LIMIT | | | FOCUS POSITION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F/NO | OBSCURED | | -.00040 | | -.00020 | | -.00000 | | .00020 | | .00040 | |
| L/MM | 2.00 | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN |
| | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .995 | .999 | .999 |
| 50 | .930 | .943 | .864 | .467 | .367 | .541 | .370 | .612 | .371 | .675 | .368 | .728 | .363 |
| 100 | .860 | .886 | .727 | .226 | .092 | .302 | .087 | .383 | .083 | .461 | .078 | .525 | .072 |
| 150 | .791 | .830 | .591 | .150 | .058 | .219 | .046 | .293 | .036 | .360 | .026 | .407 | .019 |
| 200 | .722 | .773 | .464 | .105 | .089 | .172 | .091 | .243 | .089 | .300 | .082 | .327 | .071 |
| 250 | .655 | .716 | .340 | .079 | .042 | .140 | .044 | .205 | .046 | .253 | .047 | .263 | .048 |
| 300 | .588 | .659 | .237 | .060 | .021 | .117 | .012 | .177 | .001 | .214 | .010 | .211 | .020 |
| 350 | .523 | .605 | .137 | .047 | .009 | .099 | .008 | .154 | .008 | .165 | .009 | .172 | .011 |
| 400 | .459 | .550 | .077 | .037 | .017 | .083 | .016 | .134 | .019 | .160 | .020 | .141 | .020 |
| 450 | .398 | .498 | .027 | .032 | .006 | .071 | .006 | .117 | .005 | .141 | .006 | .120 | .006 |

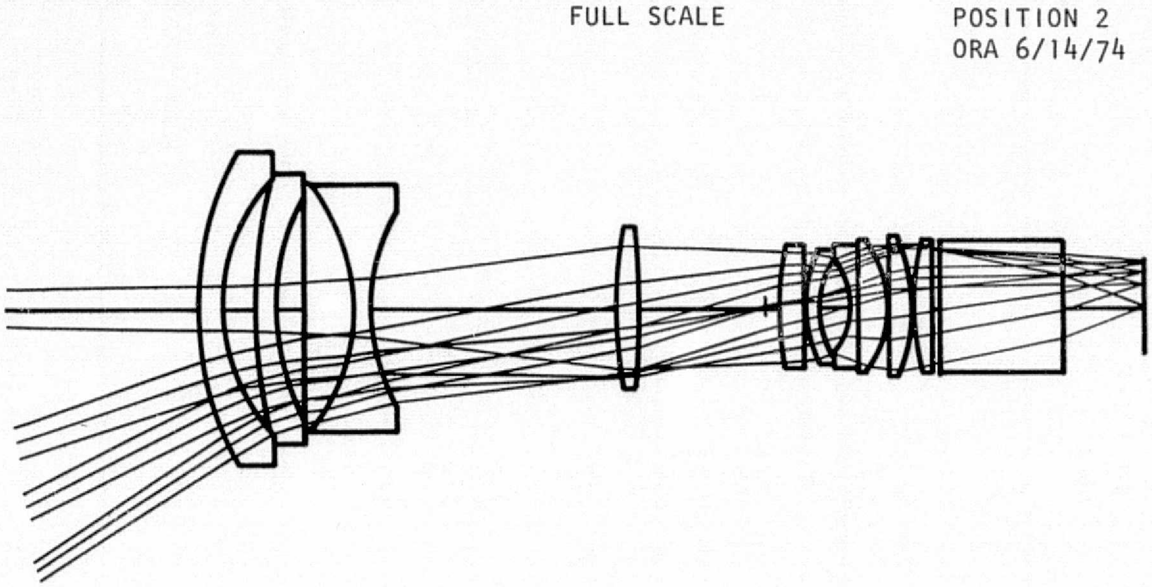


FIGURE A-3

f/1.4, 10 mm W/A Objective, at 200 mm

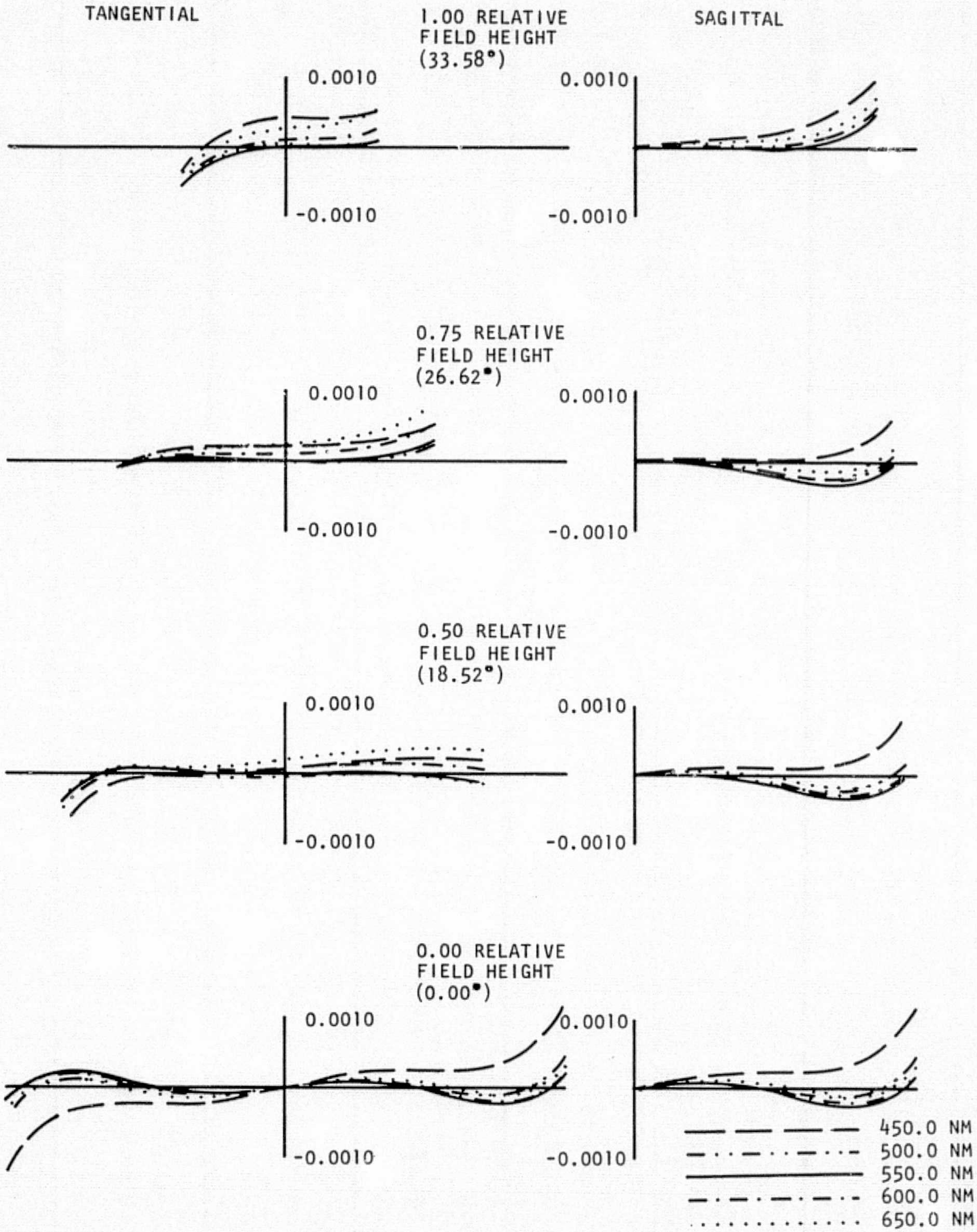


FIGURE A-4

f/1.4 W/A Objective Abberation Plots at 200 mm

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TABLE A-5

Diffraction MTF at 200 mm at 0.00°

POSITION 2 DIFFRACTION MTF ORA 6/14/74

10MM F/1.4 (AT F/2) W/A OBJECTIVE PFR-OBJ-063

FIELD POSITION = 0.00 Y MAX. ( 0.00 DEGREES)
RELATIVE ILLUMINATION =100.0 PER CENT
DISTORTION = 0.00 PER CENT

| WAVELENGTH | WEIGHT |
|---|---|
| 650.0 NM | 1 |
| 600.0 NM | 1 |
| 550.0 NM | 1 |
| 500.0 NM | 1 |
| 450.0 NM | 1 |

| | DIFFRACTION LIMIT | | | FOCUS POSITION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F/NO | OBSCURED | | -.00040 | | -.00020 | | -.00000 | | .00020 | | .00040 | |
| L/MM | 2.00 | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN |
| | .999 | .999 | | .999 | | .999 | | .999 | | .999 | | .999 | |
| 50 | .930 | .930 | | .634 | | .693 | | .731 | | .747 | | .741 | |
| 100 | .860 | .860 | | .306 | | .388 | | .433 | | .442 | | .428 | |
| 150 | .791 | .791 | | .132 | | .258 | | .323 | | .318 | | .276 | |
| 200 | .722 | .721 | | .006 | | .116 | | .229 | | .275 | | .245 | |
| 250 | .655 | .653 | | .015 | | .053 | | .132 | | .209 | | .231 | |
| 300 | .588 | .586 | | .027 | | .053 | | .102 | | .154 | | .194 | |
| 350 | .523 | .521 | | .026 | | .046 | | .103 | | .143 | | .163 | |
| 400 | .459 | .456 | | .029 | | .040 | | .100 | | .150 | | .147 | |
| 450 | .398 | .396 | | .033 | | .049 | | .106 | | .156 | | .136 | |

TABLE A-6

Diffraction MTF at 200 mm at 18.52°

POSITION 2 DIFFRACTION MTF ORA 6/14/74

10MM F/1.4 (AT F/2) W/A OBJECTIVE PFR-OBJ-063

FIELD POSITION = .50 Y MAX. ( 18.52 DEGREES)
RELATIVE ILLUMINATION =105.0 PER CENT
DISTORTION = -1.47 PER CENT

| WAVELENGTH | WEIGHT |
|---|---|
| 650.0 NM | 1 |
| 600.0 NM | 1 |
| 550.0 NM | 1 |
| 500.0 NM | 1 |
| 450.0 NM | 1 |

| | DIFFRACTION LIMIT | | | FOCUS POSITION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F/NO | OBSCURED | | -.00040 | | -.00020 | | -.00000 | | .00020 | | .00040 | |
| L/MM | 2.00 | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN |
| | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 |
| 50 | .930 | .934 | .928 | .794 | .606 | .797 | .651 | .779 | .678 | .741 | .684 | .687 | .669 |
| 100 | .860 | .869 | .856 | .525 | .307 | .533 | .309 | .514 | .286 | .477 | .257 | .430 | .236 |
| 150 | .791 | .803 | .787 | .379 | .194 | .367 | .190 | .344 | .134 | .329 | .059 | .321 | .041 |
| 200 | .722 | .738 | .717 | .328 | .129 | .303 | .146 | .256 | .111 | .235 | .042 | .241 | .031 |
| 250 | .655 | .674 | .650 | .290 | .073 | .286 | .124 | .223 | .118 | .175 | .044 | .172 | .077 |
| 300 | .588 | .610 | .583 | .243 | .049 | .267 | .104 | .210 | .114 | .138 | .066 | .115 | .108 |
| 350 | .523 | .549 | .519 | .211 | .045 | .238 | .099 | .197 | .127 | .116 | .094 | .073 | .096 |
| 400 | .459 | .487 | .454 | .198 | .035 | .206 | .085 | .169 | .120 | .094 | .093 | .040 | .058 |
| 450 | .398 | .429 | .393 | .195 | .025 | .176 | .058 | .132 | .080 | .070 | .065 | .018 | .041 |

TABLE A-7

Diffraction MTF at 200 mm at 26.26°

POSITION 2 DIFFRACTION MTF ORA 6/14/74

10MM F/1.4 (AT F/2) W/A OBJECTIVE PER-OBJ-063

FIELD POSITION = .75 Y MAX. ( 26.62 DEGREES)
RELATIVE ILLUMINATION =100.4 PER CENT
DISTORTION = -2.71 PER CENT

| WAVELENGTH | WEIGHT |
|---|---|
| 650.0 NM | 1 |
| 600.0 NM | 1 |
| 550.0 NM | 1 |
| 500.0 NM | 1 |
| 450.0 NM | 1 |

| | DIFFRACTION LIMIT | | | FOCUS POSITION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F/NO | OBSCURED | | -.00040 | | -.00020 | | -.00000 | | .00020 | | .00040 | |
| L/MM | 2.00 | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN |
| | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 |
| 50 | .930 | .938 | .923 | .825 | .448 | .817 | .496 | .789 | .536 | .743 | .567 | .682 | .587 |
| 100 | .860 | .877 | .846 | .597 | .164 | .586 | .171 | .545 | .163 | .485 | .140 | .416 | .112 |
| 150 | .791 | .816 | .771 | .431 | .170 | .428 | .200 | .408 | .205 | .376 | .182 | .333 | .145 |
| 200 | .722 | .755 | .695 | .327 | .157 | .327 | .196 | .325 | .209 | .313 | .183 | .273 | .122 |
| 250 | .655 | .693 | .620 | .269 | .105 | .258 | .129 | .260 | .117 | .254 | .059 | .217 | .050 |
| 300 | .588 | .632 | .545 | .236 | .084 | .208 | .102 | .202 | .101 | .199 | .085 | .171 | .128 |
| 350 | .523 | .575 | .474 | .217 | .079 | .173 | .117 | .155 | .150 | .155 | .156 | .139 | .145 |
| 400 | .459 | .517 | .405 | .197 | .056 | .143 | .099 | .116 | .138 | .118 | .149 | .114 | .126 |
| 450 | .398 | .462 | .337 | .175 | .032 | .117 | .064 | .085 | .091 | .090 | .093 | .095 | .090 |

## TABLE A-7

### Diffraction MTF at 200 mm at 33.58°

POSITION 2 DIFFRACTION MTF ORA 6/14/74

10MM F/1.4 (AT F/2) W/A OBJECTIVE PER-OBJ-063

FIELD POSITION = 1.00 Y MAX. ( 33.58 DEGREES)
RELATIVE ILLUMINATION = 67.3 PER CENT
DISTORTION = -3.16 PER CENT

| WAVELENGTH | WEIGHT |
|---|---|
| 650.0 NM | 1 |
| 600.0 NM | 1 |
| 550.0 NM | 1 |
| 500.0 NM | 1 |
| 450.0 NM | 1 |

| | DIFFRACTION LIMIT | | | FOCUS POSITION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F/NO | OBSCURED | | -.00040 | | -.00020 | | -.00000 | | .00020 | | .00040 | |
| L/MM | 2.00 | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN | RAD | TAN |
| | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 | .999 |
| 50 | .930 | .946 | .675 | .497 | .134 | .574 | .147 | .644 | .160 | .702 | .174 | .747 | .189 |
| 100 | .860 | .891 | .750 | .207 | .149 | .302 | .160 | .395 | .171 | .477 | .182 | .535 | .192 |
| 150 | .791 | .837 | .625 | .100 | .043 | .190 | .045 | .281 | .048 | .355 | .050 | .399 | .055 |
| 200 | .722 | .782 | .502 | .049 | .047 | .132 | .054 | .217 | .060 | .279 | .065 | .305 | .070 |
| 250 | .655 | .729 | .368 | .029 | .013 | .102 | .011 | .160 | .012 | .230 | .014 | .241 | .015 |
| 300 | .586 | .676 | .273 | .021 | .013 | .086 | .016 | .157 | .021 | .196 | .026 | .194 | .033 |
| 350 | .523 | .624 | .176 | .015 | .005 | .074 | .007 | .141 | .007 | .171 | .007 | .160 | .006 |
| 400 | .459 | .571 | .101 | .011 | .008 | .064 | .009 | .126 | .010 | .151 | .010 | .134 | .009 |
| 450 | .398 | .521 | .045 | .011 | .005 | .059 | .004 | .115 | .004 | .135 | .003 | .116 | .002 |

SPECIFICATION NUMBER
AOD 11001

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Revisions

Contract Number

Originator D G Galen Date 11/4/74

Approved [signature] Date 11-4-74

Approved [signature] Date 11/6/74

APPLIED OPTICS DIVISION
PERKIN-ELMER
COSTA MESA, CALIFORNIA

10 MM WIDE ANGLE LENS

NOV 6 1974

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Code Ident. 16735

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## 1.0 SCOPE

This specification covers a 10 mm wide angle lens for 16 mm film format with provision for splitting a portion of the received light to a sensor for automatic exposure control. The lens is being designed, built, and tested in accordance with this document, which represents Perkin-Elmer, Applied Optics Division's, understanding of the requirements of Perkin-Elmer ASD's statement of work. No obligation is implied for Perkin-Elmer, A.O.D., to fulfill any requirement not stated specifically herein.

## 2.0 APPLICABLE DOCUMENTS

Statement of Work, Perkin-Elmer ASD (no number)
Specification CF 32-A-701, NASA Manned Spacecraft Center
MIL-G-675, Coating of Optical Elements
MIL-STD-150A, Photographic Lenses
MIL-A-8625B Anodizing of Aluminum Parts
MIL-STD-810B Environmental Test Methods
MSC-PA-67-13

## 3.0 REQUIREMENTS

### 3.1 Optical Requirements

#### 3.1.1 Equivalent Focal Length

The equivalent focal length of the lens shall be 10.0 mm ± 0.2mm.

#### 3.1.2 Focusing

The lens shall meet the performance requirements when focused at any object distance from 8 inches to infinity. The object distance is measured from the front surface of the first element of the lens. Focusing of the lens shall not change the front vertex or back focal distance of the lens.

#### 3.1.3 Flange Focal Distance

The flange focal distance of the lens shall be 1.100 inches ± 0.002 inch.

3.1.4 F/Number

The lens shall have a maximum f/number of f/1.4.

3.1.5 Spectral Range

The lens shall be designed to operate over the spectral range from 435 to 650 nm.

3.1.6 Coatings

The lens elements shall be coated with magnesium fluoride per MIL-C-675, optimized for peak transmittance at 520 nm.

3.1.7 Iris

An iris shall be incorporated which will vary the lens f/number from f/1.4 to f/22. The iris shall be linear in its action; i.e., the rotation of the iris control ring through a fixed angle shall change the area of the entrance pupil by a fixed ratio at any point in the iris travel. The variation of the area of the pupil from the nominal for that angle shall not exceed 10%.

3.1.8 Relative Illumination

The relative illumination shall be greater than 25% at 0.9ø with the lens fully open.

3.1.9 Format

The lens format at the focal plane will be a 0.5 inch diagonal, represented by a 0.3 X 0.4 inch rectangular format.

3.1.10 Field of View

The lens shall cover a nominal field of view of 65°, although the format and the equivalent focal length are the governing parameters.

3.1.11 Distortion

Distortion shall be less than 3% per MIL-STD-150A.

3.1.12 Resolution

The lens shall exhibit the aerial image modulation transfer functions of Table I. The values represent the average of the radial and tangential measurements.

TABLE I

| Spatial Frequency | Axis | 0.5Ø | 0.75Ø | 1.0Ø |
|---|---|---|---|---|
| 50 lp/mm | 70% | 65% | 50% | 40% |
| 100 lp/mm | 45% | 40% | 35% | 15% |

The goal is to produce a resolution of 250 lp/mm on axis and 150 lp/mm AWAR on 3414 film, using a high contrast USAF target per MIL-STD-150A.

3.1.13 Back Focus

The lens back focus shall be a minimum of 0.425 inch.

3.1.14 Beamsplitter

A beamsplitting cube shall be incorporated in the lens behind the last element with power. This beamsplitter shall deviate not more than 10% of the light incident on its diagonal face at right angles to the optical axis. The upper face of the cube, through which the deviated beam passes, shall incorporate a lens element which will bring the field of the lens to an approximate (uncorrected) focus in a 0.200 inch diameter.

3.2 Mechanical Requirements

3.2.1 Dimensions

The outline and mounting interface dimensions shall be in accordance with ASD drawing 348456, Rev. B.

3.2.2 Marking

Marking shall be in accordance with the requirements of NASA specification CF 32-A-701, paragraph 6.5.

3.2.3 Finishes

Aluminum parts shall be anodized per MIL-A-8625B. The external finish shall be dark and dull to eliminate reflecting surfaces to the maximum practical extent.

3.2.4 Focusing Detent

A detent shall be provided at the hyper focal distance setting of the focus ring.

3.3 Environmental Requirements

The lens shall be designed to withstand the following conditions for periods of 7 days unless otherwise specified.

3.3.1 Temperature

-60°F to +200°F.

3.3.2 Vibration

3.3.2.1 Sinusoidal

5 g's from 5-2000 Hz, one sweep for 5 minutes.

3.3.2.2 Random

Per Figure I, curve A for 5 minutes (8.7 grms) and per Figure I, Curve B for 12.5 minutes (3.2 grms).

3.3.3 Humidity

120 hours of the following:

85% ± 5% relative humidity with at least 24 hours at 95%; relative temperature 70°F ± 3°F to 110°F ± 3°F to be cycled per MIL-STD-810, Method 507. The lens need not perform until after all condensation on elements due to cycling has evaporated. Beauty defects caused by condensation shall not be cause for rejection.

3.3.4 Shock

10 g's ± 0.2 g. The wave shall be sawtooth in shape with a 10 ± 1 msec rise time and 1 ± 1 msec decay time. One shock in each direction along each of three mutually per-

pendicular axes (six in all).

3.3.5 Acceleration

20 g's for 10 minutes in each of three perpendicular axes.

3.3.6 Vacuum

1 X $10^{-6}$ torr.

3.3.7 Oxygen

3.3.7.1 Environment

At a maximum pressure of 100% $^{+0\%}_{-5\%}$.

3.3.7.2 Oxygen Compatibility

A sample of the above atmosphere is analyzed per Test 7, MSC-PA-D-67-13. Total organics content shall be less than 100 mg/Kg. Carbon monoxide content shall be less than 25 mg/Kg.

3.3.8 Explosive Decompression

The lenses shall not be damaged or fractured as a result of decompression from 6 psia to 1 mm Hg in 60 seconds.

3.3.9 Fungus

The lenses shall be made from non-nutrient materials.

3.3.10 Other

The lens may possibly be exposed to salt spray, salt atmosphere, and precipitation. This possibility shall be considered in the design, and insofar as practical the lens shall be designed to resist such environments.

4.0 QUALITY ASSURANCE

## 4.1 Acceptance Tests

The following tests shall be conducted on the lens by Perkin-Elmer, Applied Optics Division.

### 4.1.1 Equivalent Focal Length

Measure per MIL-STD-150A.

### 4.1.2 F/Number

Measure per MIL-STD-150A.

### 4.1.3 Iris Linearity

Verify that the lens is within 10% of the nominal f/number at f/2.8, f/5.6, f/11, and f/22, or at any four f/numbers at the option of Perkin-Elmer, ASD.

### 4.1.4 Relative Illumination

Measure per MIL-STD-150A.

### 4.1.5 Distortion

Measure per MIL-STD-150A.

### 4.1.6 Resolution

Measure the modulation transfer function at the spatial frequencies and field positions of Table I, with the lens at f/2.0. Determine the limiting resolution on Eastman Kodak 3414 film photographically at infinity.

### 4.1.7 Mechanical

The lens shall be inspected to insure that the outline and mounting interface dimensions are in accordance with Perkin-Elmer, ASD, drawing 348456, Revision B. The lens will be inspected to insure that high standards of workmanship have been observed in its manufacture.

## 4.2 Qualification Tests

No qualification tests will be performed by Perkin-Elmer AOD. In the event of a failure of the lens under ASD qualification testing, AOD will provide technical assistance to ASD to allow correction of the defect.

## 5.0 PREPARATION FOR DELIVERY

The lens will be packaged per Perkin-Elmer, Applied Optics Division's standard packing procedure for high-quality optical components.

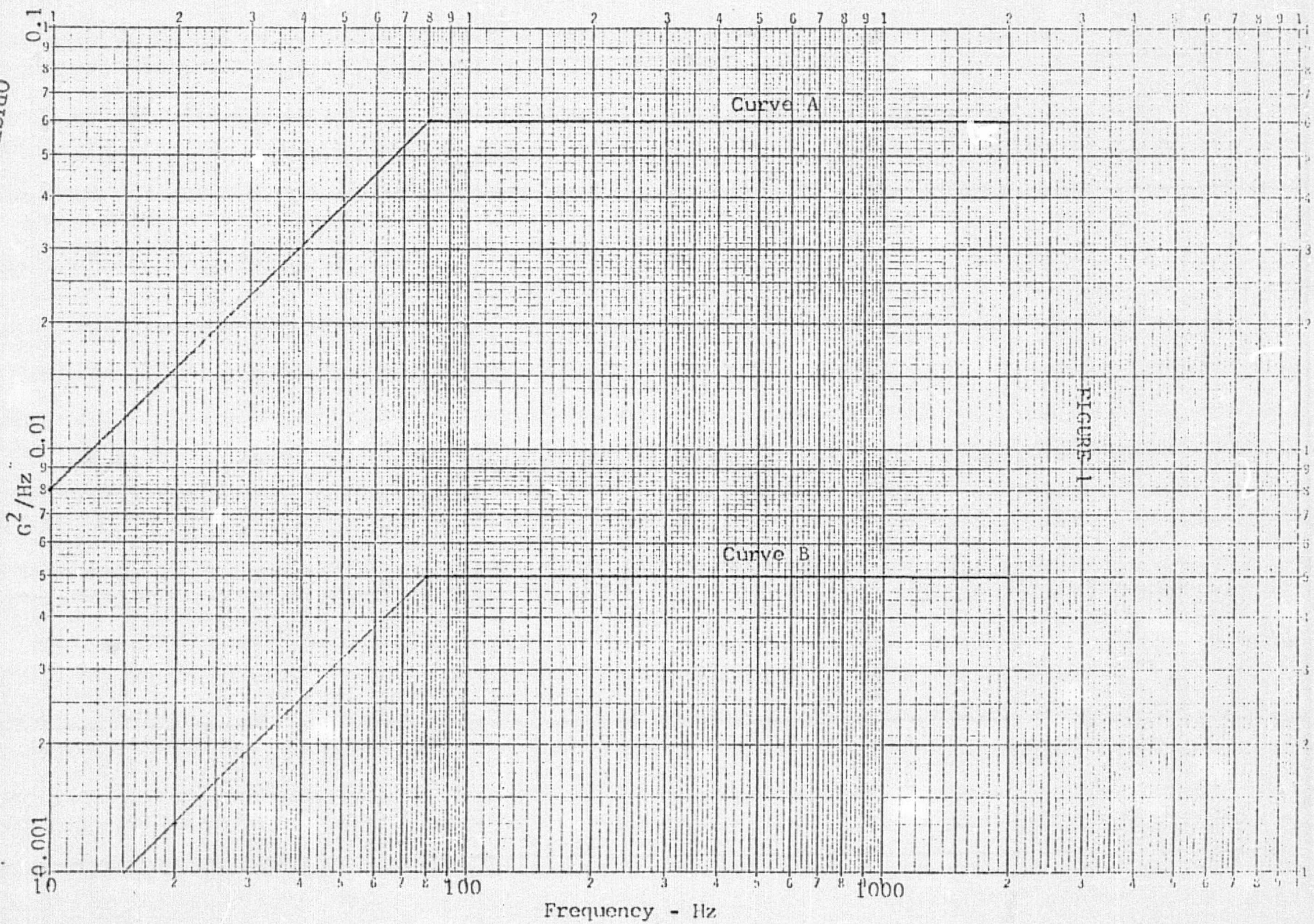


FIGURE 1

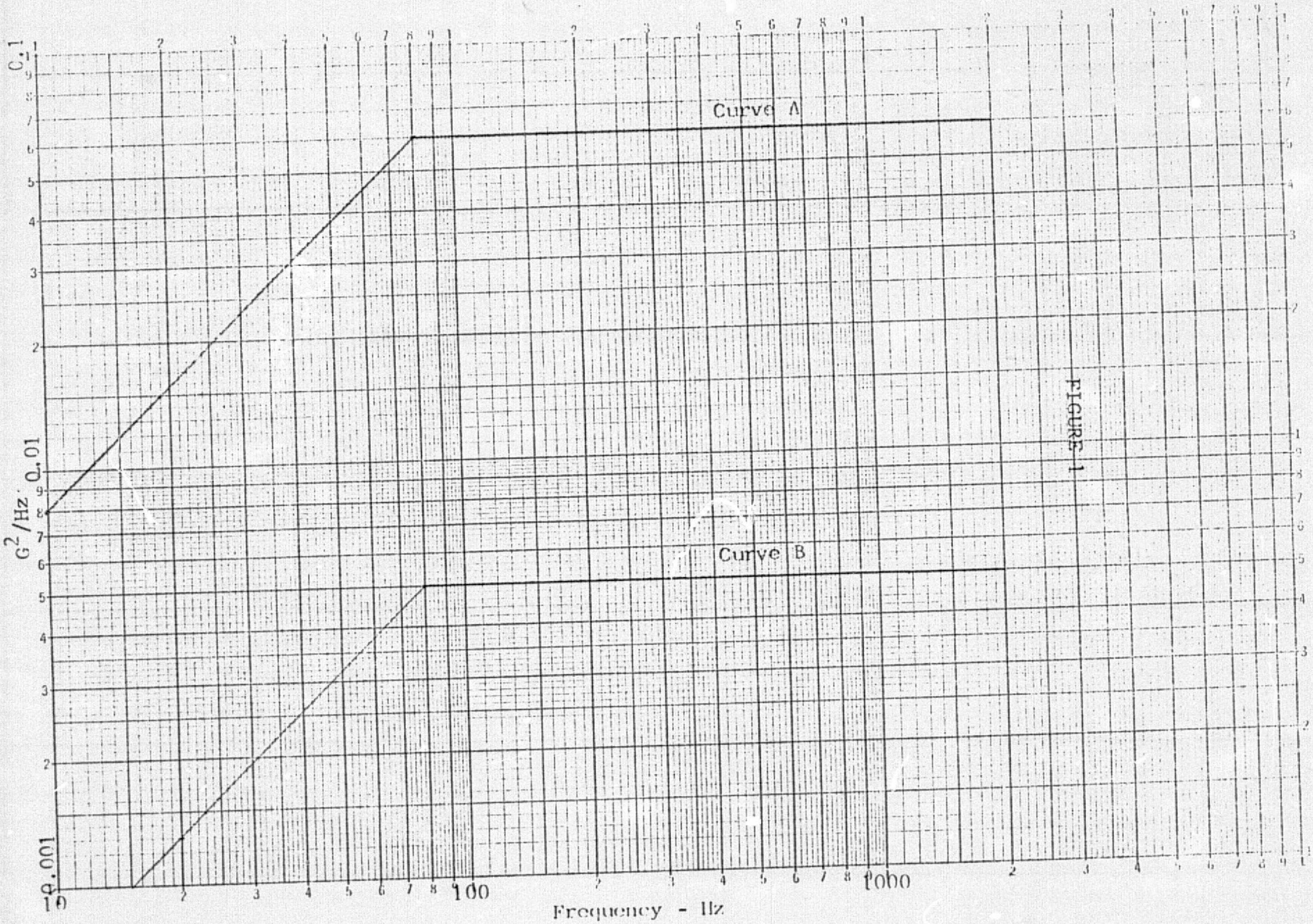


FIGURE 1

# PROJECT DOCUMENT COVER SHEET

ACCEPTANCE TEST PLAN/PROCEDURE
FOR THE
AUTOMATIC EXPOSURE IRIS
CONTROL SYSTEM
P/N 348550
FOR DATA ACQUISITION CAMERA
P/N SEB33100100

| REPORT NUMBER | DATE |
|---|---|
| ATP 82-0248 | 8-21-74 |

| | |
|---|---|
| PREPARED BY: | Geo. E. Mc Atee Jr. |
| APPROVED: | (BRANCH AND/OR SUPPORT OFFICE) Ronald H. Gerlach 8/23/74 |
| APPROVED: | |
| APPROVED: | |

NO. OF PAGES 16

| REVISIONS | | | | | |
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| DATE | PREPARED BY | APPROVALS | | | CHG. LETTER |
| | | BRANCH | DIVISION | PROGRAM OFFICE | |
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REPORT NUMBER

MSC FORM 151A (JUL 66)

| APPLICATION | | REVISIONS | | | |
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| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES<br>TOLERANCES<br>ANG ±0°30'<br>DEC .XX ± .XXX ± | CONTRACT NO. | **PERKIN-ELMER**<br>AEROSPACE DIVISION |
| MATERIAL: | DWG NO.<br>DRAWN Geo. E. McAtee 8/21/74<br>CHKD 8/22/74<br>DESIGN | ACCEPTANCE TEST PLAN/PROCEDURE FOR THE AUTOMATIC EXPOSURE IRIS CONTROL SYSTEM P/N 348550 FOR DATA ACQUISITION CAMERA P/N SEB33100100 |
| | | SIZE A — CODE IDENT NO. 26581 — ATP 82-0248 |
| | | SCALE — SHEET 1 of 15 |

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# LIST OF APPLICABLE DOCUMENTS

| | | |
|---|---|---|
| 1. | CF32-A-118 | Acceptance test procedure for 16 mm Data Acquisition Camera PN SEB 33100100 |
| 2. | NPC 200-4 | Quality requirements for hand soldering of electrical connections |
| 3. | MIL-STD-150A | Military Standard Photographic lenses |
| 4. | 72-0040 | (Perkin-Elmer), Operation procedure for Automatic Exposure Iris Control |

## TEST EQUIPMENT

1. Power supply, 0 to 35 V dc @ 3 A, regulated Power Design Model 3650 or equiv.

2. Calibrated light source, 39 to 10,000 fL, Spectra No. 2397

3. Fixture, photo diode receiver No. 348494

4. Fixture, camera holding No. 348495

5. Recorder, strip chart Honeywell Visicorder/Signal Conditioner System PN 16794815-001, SN 36644

6. Ammeter, 0 to 1 A

7. Timer, automatic No. 348496

## 1.0 PURPOSE

1.1 The purpose of this procedure is to test the Automatic Exposure Iris Control (AEIC) on the Data Acquisition Camera (DAC) for acceptance criteria.

## 2.0 REQUIREMENTS

2.1 The AEIC/DAC shall meet the following requirements:

a. Automatically compensate for a scene brightness range of 39 to 10,000 foot Lamberts (fL) in 1/4 f stops, by adjusting the lens iris from f 1.4 to f 22.

b. Automatically compensate the AEIC for manual selection of film sensitivities of ASA 25, 64, 80, 160, 250, 500, 1000, and 2000.

c. Automatically compensate the AEIC for manual selection of shutter speeds of 1/60, 1/125, 1/250, 1/500 and 1/1000 seconds.

d. The AEIC/DAC shall perform with a power consumption of less than 936 mA at 28 V dc.

e. The AEIC shall not degrade the performance of the standard DAC.

f. The AEIC shall operate only when the DAC trigger is activated.

## 3.0 TEST CONDITIONS

3.1 All tests shall be conducted under the following standard conditions:

a. Test temperature shall be 75 ±5°F.

b. Relative humidity shall be 60 ±20%.

c. Barometric pressure shall be laboratory ambient.

## 4.0 METHOD OF DEMONSTRATION

4.1 The AEIC/DAC shall be mounted to test fixture 348495 so that the lens is aligned with the output port of a calibrated light source. Install light sensing fixture 348494. The results of the adjustments made by the AEIC shall be measured through the positioning of a light sensitive cell at the film plane of the DAC. The cell output shall be monitored by a strip chart recorder. The data on the chart will be evaluated, recorded on the data record sheets and made a permanent part of the test data.

The recorder/amplifier will respond in a linear manner to the light level received by the sensor at the DAC film plane. Therefore, each f stop change in light level will be recorded as an equal change in wave form amplitude. Subsequently, each 1/4 or 1/2 f stop change will be a proportional increment of a full f stop change amplitude. A 0 to 1 A/mA meter shall be in series with the AEIC/DAC and the 28 V dc power source so that the total current drawn can be observed and recorded.

5.0 TEST DEMONSTRATION

5.1 Automatic iris compensation for changes in scene brightness.

5.1.1 Set the AEIC/DAC shutter speed control to 1/250 s (34.5°), the DAC frame rate to 6, the film sensitivity control to ASA 80, light source controls to produce an output of 39 fL, and strip recorder to 2 inches per second.

a. Activate light source

b. Start recorder

c. Trigger DAC and allow unit to run for approximately 6 seconds

d. Deactivate recorder and record test paragraph number on the strip chart

5.1.2 Increase light source output in 1/4 stop increments to 46.4, 55.2, 65.6 and 78 fL while repeating steps b through d at each setting.

5.1.3 Increase the light source output in 1 stop increments to 156, 312, and 625 fL while repeating steps b through d at each setting.

5.1.4 Increase the light source output in 1/4 stop increments to 742.4, 883, 1048, and 1250 fL while repeating steps b through d at each setting.

5.1.5 Increase the light source output in 1 stop increments to 2500 and 5000 fL while repeating steps b through d at each setting.

5.1.6 Increase the light source output in 1/4 stop increments to 5940, 7068, 8394, 10,000 fL while repeating steps b through d at each setting.

5.1.6.1 Deactivate the light source, remove strip chart, evaluate and record results on test data sheet.

5.1.6.2 The wave form recorded on the strip chart shall be of equal widths and amplitudes. The amplitude portion of the wave form is maintained constant by the automatic lens iris compensation for each change in scene brightness. The amplitude shall remain constant for each light input setting within ±1/4 f stop.

5.2 Automatic Iris Compensation for Manual Changes in Film Sensitivity

5.2.1 Set the AEIC/DAC film sensitivity switch to ASA 25 and the shutter speed control to 1/250 second (34.5°), light source output to 22.8 fL and activate light source.

a. Repeat Paragraph 5.1.1b. thru d.

b. While maintaining the same shutter speed, change DAC film sensitivity switch to ASA 64, 80, 160, 250, 500, 1000, and 2000. Repeat Paragraph 5.1.1b. thru d. for each ASA setting.

c. Deactivate light source

d. The wave form recorded on strip chart will vary in amplitude with each change in film sensitivity.

e. The amplitude shall indicate the following changes: from 25 to 64 ASA - 1 f stop; from 64 to 80 ASA - 1/2 f stop; from 80 to 160 ASA - 1 f stop; from 160 to 250 ASA - 1/2 f stop; at 250, 500, 1000, and 2000 ASA - 1 f stop each.

5.3 Automatic Iris Compensation for Manual Changes in Shutter Speeds

5.3.1 Set the AEIC/DAC film sensitivity switch to ASA 80 and the shutter speed control to 1/1000 (8.6°), light source output to 156 fL and activate light source.

a. Repeat Paragraph 5.1.1b. thru d.

b. While maintaining the same ASA setting, change the shutter speed to 1/500 (17.3°), 1/250 (34.5°), 1/125 (69°), and 1/60 (138°).

c. Repeat Paragraph 5.1.1b. thru d.

d. Deactivate light source, then remove strip chart, evaluate, and record results on data sheet.

e. The waveform recorded on strip chart will vary in both amplitude and width. Only the amplitude variation is measured for this evaluation. The width variation is disregarded. The amplitude indication will be 1 full f stop change for each shutter speed setting.

5.4 Power Consumption Limit Verification

5.4.1 Reset any combination of AEIC/DAC controls to produce a change from the static state. Activate the light source. Trigger the AEIC/DAC and observe the current drawn during the transient state. The total current drawn shall not exceed 936 mA at 28 V dc.

5.5 The AEIC shall not degrade the performance of the standard DAC.

5.5.1 The DAC shall be retested per CF32-A-118 to verify the modification impact on the standard DAC. The data taken as a result of this retest shall be compared to the data recorded on the original acceptance test. The maximum operation current allowed for the modified DAC is 936 mA at 28 V dc. All other data comparisons shall indicate no functional degradation as a result of the modification.

5.6 AEIC operation with respect to DAC state.

5.6.1 Verify that 28 V dc is connected to the DAC but that the trigger signal is not activated. Operate any combination of controls. The AEIC shall not respond. Activate the DAC trigger signal. The AEIC shall respond to the control settings selected. Deactivate light source.

5.7 Photographic Test, Gray Scale

5.7.1 Load the DAC film magazine with type 3400 film and attach the magazine to the DAC.

5.7.1.1 Set DAC ASA control to 80, shutter speed control to 1/250 (34.5°), frame rate control to 6, and light source controls to produce an output of 39 fL.

a. Activate the light source.

b. Trigger the DAC and allow the unit to run for approximately 5 seconds.

c. Increase light source output to 78, 156, 312, 625, 1250, 2500, 5000 and 10,000 fL while repeating steps a and b at each setting.

d. Cover unit lens and trigger unit for approximately 1 second.

e. Deactivate light source.

f. Down load magazine and process film using KODAK D-19 developer at 68 to 70° for 8 minutes.

g. Rinse and fix emulsion, thoroughly dry film before proceeding with the evaluation.

5.7.1.2 The film density shall be measured by back lighting the film and measuring the resultant density with a photodensitometer as follows:

a. Position film on an evenly lighted, diffused surface light source.

b. Position the densitometer sensor so that 1 frame of the first test sequence is viewed in the center of the frame.

c. Read frame by frame, the last 10 frames of each test sequence. Average the readings and record the resultant density variations. The frame to frame variations within a sequence shall not exceed ±10%. The variation from one test sequence to another shall not exceed 25%.

5.8 Photographic Test, Typical Scene

5.8.1 The typical scene photographic test is intended to produce footage which is representative of the actual material, using natural lighting and subjects rather than laboratory props. This footage shall be visually examined for correct exposure and balance. The test will be accomplished as follows:

a. Load DAC film magazine with Ektachrome type MS color film.

b. Attach the magazine to the DAC.

c. Set DAC frame rate to 12 frames per second, shutter speed to 1/125 (69°) and ASA compensation to 64.

d. Photograph a subject which displays high and low contrast, direct, indirect, and deep shade lighting. This photography shall be accomplished in such a way as to display scenes covering the times between sun rise and sunset.

e. Down load the film magazine and forward the film to NASA JSC for processing.

f. Upon receipt of the film, representatives of NASA and the contractor shall evaluate the results of this test.

Unit Response to Light Input

| | 19 fL | | | | | | | 625 fL | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASA | 40 | 80 | 160 | 320 | 640 | 1280 | 2560 | 40 | 80 | 160 | 320 | 640 | 1280 | 2560 |
| 8.6° | | | | | 1.4 | 2 | 2.8 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 16 |
| 17.3 | | | | 1.4 | 2 | 2.8 | 4 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 22 |
| 34.5 | | | 1.4 | 2 | 2.8 | 4 | 5.6 | 4 | 5.6 | 8 | 11 | 16 | 22 | |
| 69 | | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 5.6 | 8 | 11 | 16 | 22 | | |
| 138 | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 8 | 11 | 16 | 22 | | | |

| | 39 fL | | | | | | | 1250 fL | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASA | 40 | 80 | 160 | 320 | 640 | 1280 | 2560 | 40 | 80 | 160 | 320 | 640 | 1280 | 2560 |
| 8.6° | | | | 1.4 | 2 | 2.8 | 4 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 22 |
| 17.3 | | | 1.4 | 2 | 2.8 | 4 | 5.6 | 4 | 5.6 | 8 | 11 | 16 | 22 | |
| 34.5 | | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 5.6 | 8 | 11 | 16 | 22 | | |
| 69 | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 8 | 11 | 16 | 22 | | | |
| 138 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 11 | 16 | 22 | | | | |

| | 78 fL | | | | | | | 2500 fL | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASA | 40 | 80 | 160 | 320 | 640 | 1280 | 2560 | 40 | 80 | 160 | 320 | 640 | 1280 | 2560 |
| 8.6° | | | 1.4 | 2 | 2.8 | 4 | 5.6 | 4 | 5.6 | 8 | 11 | 16 | 22 | |
| 17.3 | | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 5.6 | 8 | 11 | 16 | 22 | | |
| 34.5 | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 8 | 11 | 16 | 22 | | | |
| 69 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 11 | 16 | 22 | | | | |
| 138 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 22 | 16 | 22 | | | | | |

| | 156 fL | | | | | | | 5000 fL | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASA | 40 | 80 | 160 | 320 | 640 | 1280 | 2560 | 40 | 80 | 160 | 320 | 640 | 1280 | 2560 |
| 8.6° | | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 5.6 | 8 | 11 | 16 | 22 | | |
| 17.3 | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 8 | 11 | 16 | 22 | | | |
| 34.5 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 11 | 16 | 22 | | | | |
| 69 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 22 | 16 | 22 | | | | | |
| 138 | 4 | 5.6 | 8 | 11 | 16 | 22 | | | | | | | | |

| | 312 fL | | | | | | | 10,000 fL | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASA | 40 | 80 | 160 | 320 | 640 | 1280 | 2560 | 40 | 80 | 160 | 320 | 640 | 1280 | 2560 |
| 8.6° | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 8 | 11 | 16 | 22 | | | |
| 17.3 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 11 | 16 | 22 | | | | |
| 34.5 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 22 | 16 | 22 | | | | | |
| 69 | 4 | 5.6 | 8 | 11 | 16 | 22 | | 22 | | | | | | |
| 138 | 5.6 | 8 | 11 | 16 | 22 | | | | | | | | | |

SPECTRA LUMINANCE STANDARD

CODE #2397 #1957

Calibrated on March 11, 1974

| fL | MICROMETER SETTINGS | | | |
|---|---|---|---|---|
| | 5500 K W/OB8 W/ND1.0 103.3 Volts | 5500 K W/OB8 101.2 Volts | 2870 K No Filter 90.6 Volts | 3130 K No Filter 114.1 Volts |
| 39.0 | 0.975 | | | |
| 46.4 | 0.994 | | | |
| 55.2 | 1.018 | | | |
| 65.6 | 1.049 | | | |
| 78. | 1.086 | 0.857 | | |
| 92.8 | 1.137 | 0.867 | | |
| 110.4 | 1.208 | 0.877 | | |
| 131 | 1.315 | 0.887 | | |
| 156 | 1.507 | 0.899 | | |
| 185.6 | | 0.910 | | |
| 220.8 | | 0.922 | | |
| 262 | | 0.935 | | |
| 312 | | 0.950 | 0.856 | |
| 371.2 | | 0.966 | 0.866 | |
| 441.6 | | 0.985 | 0.877 | |
| 524 | | 1.007 | 0.888 | |
| 625 | | 1.035 | 0.899 | 0.858 |
| 742.4 | | 1.069 | 0.911 | 0.868 |
| 883 | | 1.114 | 0.924 | 0.878 |
| 1048 | | 1.175 | 0.936 | 0.888 |
| 1250 | | 1.269 | 0.952 | 0.900 |
| 1485 | | 1.415 | 0.968 | 0.911 |
| 1767 | | 1.772 | 0.988 | 0.924 |
| 2096 | | | 1.011 | 0.936 |
| 2500 | | | 1.040 | 0.952 |
| 2970 | | | 1.076 | 0.967 |
| 3534 | | | 1.123 | 0.986 |
| 4192 | | | 1.188 | 1.008 |
| 5000 | | | 1.284 | 1.037 |
| 5940 | | | 1.442 | 1.074 |
| 7068 | | | 1.886 | 1.120 |
| 8394 | | | | 1.182 |
| 10000 | | | | 1.279 |

Data Record for Acceptance Test Procedure 82-0248.

The chart produced by the strip chart recorder shall be clearly labeled with the Serial No. of the test unit, date, and the name of the technician taking the data. The chart shall be retained as part of this data record.

Record of test result.

Ref. Para.

5.1 Automatic iris compensation for changes in scene brightness

Criteria:

Waveform amplitude shall not vary more than ±1/4 f stop (1/4 f stop = 0.312 V)

| | Light Input (fL) | Waveform Amplitude | Variation | Full open @ f1.4. |
|---|---|---|---|---|
| Initial Point | 39 | 4.463 | 0.228 | |
| | 46.4 | 4.692 | 0.001 | |
| | 55.2 | 4.969 | 0.278 | |
| | 65.6 | 4.882 | 0.191 | |
| Low / Nom. Volts / High | 78 | 4.946 | 0.255 | |
| 4.37 / 4.691 / 5.01 | 156 | 4.884 | 0.193 | |
| | 312 | 4.949 | 0.258 | |
| | 625 | 4.837 | 0.146 | |
| | 742.4 | 4.888 | 0.197 | |
| | 883 | 4.979 | 0.288 | |
| | 1048 | 4.998 | 0.307 | |
| | 1250 | 4.782 | 0.093 | |
| | 2500 | 4.842 | 0.131 | |
| | 5000 | 5.801 | 1.111 | End of travel. (see Note, bottom of page 14) |
| | 5940 | 6.042 | | |
| | 7068 | | | |
| | 8394 | | | |
| | 10000 | | | |

| SIZE | CODE IDENT NO. | |
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Ref. Para.

5.2 Automatic iris compensation for manual changes in film sensitivity

Criteria:

Waveform amplitude as recorded shall be within ±1/4 f stop of predicted amplitude.

| ASA Selection | Predicted Amplitude (V) | | | Actual | Variation Full Open f1.4 |
|---|---|---|---|---|---|
| | Low | Nom. | High | | |
| 25 | 4.37 V | 4.69 V | 5.01 V | 2.456 | 2.235 |
| 64 | | | | 3.758 | 0.933 |
| 80 | | | | 4.385 | 0.306 |
| 160 | | | | 4.794 | 0.103 |
| 250 | | | | 4.937 | 0.248 |
| 500 | | | | 4.741 | 0.051 |
| 1000 | | | | 4.801 | 0.110 |
| 2000 | | | | 5.020 | 0.325 End of range. |

5.3 Automatic iris compensation for manual changes in shutter speed (see Note, bottom of page 14)

Criteria:

Waveform amplitude as recorded shall be within ±1/4 f stop of predicted amplitude

| Shutter Speed Selection | Predicted Amplitude (V) | | | Actual | Variation Full Open f1.4 |
|---|---|---|---|---|---|
| | Low | Nom. | High | | |
| 1/1000 second | 4.37 V | 4.69 V | 5.01 V | 4.436 | 0.255 |
| 1/500 second | | | | 4.977 | 0.276 |
| 1/250 second | | | | 4.829 | 0.138 |
| 1/125 second | | | | 4.880 | 0.189 |
| 1/60 second | | | | 4.801 | 0.110 |

5.4 Power consumption limit verification

Criteria:

The DAC/AEIC shall not draw more than 0.936 A at 28 V dc

Unit current measures 0.680 A

5.5 The AEIC shall not degrade the performance of the standard DAC

Criteria:

The test data of the modified DAC shall indicate no degradation when compared to the standard DAC test data, with the exception of the maximum allowed current of 936 mA at 28 V dc

Unit meet criteria Yes

Unit does not meet criteria ________

5.6 AEIC operation with respect to DAC state

Criteria:

The AEIC shall not operate unless the DAC trigger is activated

Unit meets criteria Yes

Unit does not meet criteria ________

5.7 Photograph Test, Gray Scale

| | | | | | | | | Avg. |
|---|---|---|---|---|---|---|---|---|
| f1.4 | 39 | fL density | 1.15/1.2 | 1.15/1.2 | 1.2/1.2 | 1.15/1.2 | 1.2/1.2 | 1.19 |
| f2 | 78 | | 1.25/1.2 | 1.2/1.25 | 1.2/1.2 | 1.2/1.2 | 1.25/1.2 | 1.22 |
| f2.8 | 156 | | 1.3/1.3 | 1.3/1.3 | 1.3/1.3 | 1.3/1.3 | 1.3/1.3 | 1.3 |
| f4 | 312 | | 1.3/1.3 | 1.3/1.3 | 1.3/1.3 | 1.3/1.3 | 1.3/1.3 | 1.3 |
| f5.6 | 625 | | 1.3/1.25 | 1.25/1.3 | 1.3/1.35 | 1.4/1.4 | 1.35/1.35 | 1.33 |
| f8 | 1250 | | 1.1/1.1 | 1.1/1.05 | 1.1/1.05 | 1.1/1.1 | 1.1/1.1 | 1.09 |
| f11 | 2500 | | 1.1/1.1 | 1.1/1.15 | 1.1/1.1 | 1.15/1.1 | 1.1/1.1 | 1.1 |
| S/B f16 | 5000 | | *1.6/1.6 | 1.6/1.6 | 1.6/1.6 | 1.6/1.6 | 1.6/1.6 | 1.6 |
| S/B f22 | 10000 | | *2.2/2.25 | 2.2/2.2 | 2.25/2.2 | 2.2/2.2 | 2.2/2.2 | 2.21 |

Density variation shall not exceed 10% frame to frame within a sequence or ±25% from one sequence to another

Unit meets ________ does not meet * criteria

*Due to design limitations, iris closure is limited to f11 +1/4 stop. See Section 1 of the final report.

STAMP

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5.8 Photographic Test, Typical Scene

Visual Examination

Evaluate footage produced by Paragraph 5.8.1 for correct exposure and balance. Record comments.

| Name | Title/Organization | Comment |
|---|---|---|
| | | Exposure and balance with Type 3400 B. and |
| | | W. film completely satisfactory. Tests |
| | | with color film are still in process. |
| | | Results will be reported in an addendum. |
| | | |

Data taken by B. Fall date MAR 14-75

Witnessed by Geo. E. McCleef Jr. date 14 Mar. '75

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